FINAL REPORT

WHITCHURCH-STOUFFVILLE GROUNDWATER CHEMICAL TESTING PROGRAM

November, 1982

Ontario

Ministry of the Environment

The Honourable
Keith C. Norton, Q.C.,
Minister

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Deputy Minister

WHITCHURCH-STOUFFVILLE GROUNDWATER CHEMICAL TESTING PROGRAM

FINAL REPORT
NOVEMBER 1982

Laboratory Services and Applied Research Branch
Ontario Ministry of the Environment

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Ministry
of the
Environment

November 29, 1982

MEMORANDUM:

To: Report Recipients

From: M. G. Foster
Chief, Mass Spectrometry Services

Re: Erratum on Final Report - Whitchurch-Stouffville Groundwater Chemical Testing Program - November 1982

Please attach this memo to the recently issued Final Report of the Whitchurch-Stouffville Groundwater Chemical Testing Program.

An obvious typing error has been found on page 50, paragraph 3, the section on the Tranmer well should read:

The Tranmer Well was selected as a control well, which had exhibited localised impacts which could not be related to the landfill site, due to hydrogeological considerations.

Please make the appropriate correction.

MG Foster

M. G. Foster

MGF:mmp

Disclaimer

The reader is cautioned to consider this report in its entirety. Reliance upon or use of any individual segment of this report without consideration of the whole document may be misleading and could possibly lead to erroneous conclusions.

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Laboratory Services Branch	Central Region
M. Glenys Foster	Alex Giffen
Otto Meresz	Ken Hogg
Joseph Osborne	Walter Painting
Jane E. Pagel	Derek Smith
Gerald A. V. Rees	Louise Zerter
R. Dean Smillie	
George Wyhovszky	

In addition, the painstaking and patient typing of this report by Mary M. Parker is also gratefully acknowledged.

II INTRODUCTION

The waste disposal area, known today as York Sanitation No. 4 landfill site has been the subject of investigations for over 15 years. Further to a continuous quarterly monitoring program that commenced in 1976 and extensive analytical testing of selected private wells during the summer of 1981, the Ontario Ministry of the Environment initiated an in-depth chemical and biological study in December 1981. This investigation was a follow-up of the findings of a university laboratory which, in November 1981, reported bacterial mutagenicity in a concentrated water sample from one of the Whitchurch-Stouffville private wells adjacent to the York Sanitation No. 4 landfill site.

A. STUDY OUTLINE

The design of the study and selection of wells (see map in Appendix F for sample site locations) was discussed with the town's consultant and Stouffville citizens' representatives on January 5, 1982, to obtain their input and agreement. Two private wells adjacent to the landfill site were chosen for this intensive chemical investigation. In addition, two wells which could not be affected by the site based on hydrogeologic considerations were selected as "background" wells. Two wells which could not be affected by the site hydrogeologically but which exhibited localised impacts were chosen as "control" wells. These background and control wells were therefore expected to provide a good source of reference data. The selected off-site wells and sampling schedule were as follows:

Jan. 25	Ballantrae Plaza (background well)
Feb. 8	Hutchinson (adjacent to landfill site)
Feb. 22	Ministry of Natural Resources (M.N.R.) (background well)
Mar. 8	Fockler (adjacent to landfill site)
Mar. 22	Tranmer (control well)
Mar. 29	Coughlan (control well).

Three on-site observation wells (OW 16-70, OW 2-75 and OW 1-80) and leachate well 5 were also selected for investigation in co-operation with the town's consultant and Stouffville citizens' representatives. A highly specific finger-printing approach was applied to these wells which were chosen because, based on regular monitoring data, they reflected the highest on-site level of contamination observed. By this approach, it was hoped that specific constituents could be identified in on-site wells and could then be screened for in private wells to provide a more specific indicator of any potential migration from the landfill site.

All samples were subjected to very extensive chemical and microbiological testing. In an attempt to provide the most exhaustive analytical approach possible, samples were also extracted and analysed by gas chromatography/mass spectrometry (GC/MS). The newly available priority pollutant scan was applied to the private off-site wells. In combination with GC/MS, this scan, which was applied for the first time in this study, is capable of detecting some compounds not normally detected in routine scans.

In order to provide an independent data base for comparison purposes, samples from several off-site wells were sent for corroborative or additional analyses to two outside laboratories. (Detailed reports from both laboratories are included in Appendices D and E).

It should be noted when interpreting these results that, although extensive in scope, this study is based primarily on single sample testing and is therefore representative of only one point in time.

B. SUMMARY OF OBJECTIVES:

The objectives of this study can be summarized as follows:

1) To analyse the contents of leachate well 5 in order to identify and determine the nature and levels of on-site chemicals in proximity to former lagoon 5.

2) To analyse water in selected observation wells to identify any chemicals appearing in the on-site groundwater.

3) To analyse two selected off-site private wells adjacent to the landfill site to determine whether industrial chemicals detected on-site are appearing in the private drinking water supplies.

4) To determine, with higher than usual sensitivity, background levels of chemicals in wells not affected by the landfill site, with and without localised impacts on water quality.

5) To establish, by exhaustive chemical testing using a fingerprinting approach, a trace organic profile of the on-site contamination which can be used to test for any present or future migration which might create a health hazard in off-site private wells, and to provide a chemical data base to complement any mutagenicity test findings.

It was not considered practical within the scope of this report to relate the analysis results to past chemical trends.

III CHARACTERISATION OF LEACHATE WELL 5*

This section of the report describes the various analytical methods used in characterising the major components of leachate well 5. Multistage testing and confirmation was required for this complex sample.

A. ANALYTICAL METHODS AND RESULTS

1) Sample Description

Leachate well 5 is stratified with an oily layer of approximately 0.5 to 1.0 metre in the upper zone of a 7.7 metre liquid column. Samples from this well were heterogeneous consisting of an upper oily organic phase and a lower aqueous layer. Analytical work was concentrated on the organic layer, as because of the physico-chemical partition, it would be expected to contain the highest concentration and broadest spectrum of organics present at that location. The oil layer consisted of a light brown coloured material with a strong, unpleasant p-cresol type odour.

2) Gas Chromatography of Sample

The analysis of this sample was carried out using documented standard conditions for routine petroleum hydrocarbons. Because some volatile components were expected, gasoline and diesel fuel standards were run first for comparison.

A 5 uL aliquot of the sample was dissolved in 1 mL of n-hexane and 5 uL of this solution was injected into the gas chromatograph. The gas chromatogram obtained indicated a mixture of gasoline and lubricating-type oil. Components characteristic of diesel fuel and home heating oil were absent.

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* In this and subsequent sections where results are discussed, concentrations are expressed as milligrams per litre (mg/L = ppm = one part in 1,000,000), micrograms per litre (ug/L = ppb = one part in 1,000,000,000) or nanograms per litre (ng/L = ppt = one part in 1,000,000,000,000). The letter u is used to represent μ (micro) throughout this report.

3) Determination of Volatile (Low Boiling) Components

Approximately 500 mg of the sample was weighed into an evaporating dish and heated over a steam bath for 18 hours. The quantity of volatile fraction was calculated from the weight loss:

Loss of volatiles: 24.3%

4) Fingerprinting (IR) of the Oil after Evaporation of Volatiles

Samples were introduced to demountable sodium chloride cells and their infrared spectra (4000 cm^{-1} - 650 cm^{-1}) were recorded using a Beckman 4240 infrared spectrophotometer. The recorded spectra will serve as reference for comparison with samples collected from the same leachate well in future monitoring.

The spectra indicated that the material consisted mainly of a wide variety of hydrocarbons of petroleum origin with a relatively wide boiling range. The presence of other types of organic materials was indicated by a sharp ester band at 1740 cm^{-1} as well as some aromatic compounds (based on absorption at 1610 cm^{-1} and 810 cm^{-1}). The presence of phosphate esters was also indicated at 970 cm^{-1}. The last two groups of components, however, can be constituents from petroleum products.

5) Separation and Characterisation of Components

An aliquot of the residue obtained on removal of the volatile components was separated by column chromatography with sequential solvent elution. Fractions were characterised by infrared spectrophotometry as follows:

a) paraffinic base oil	73.5%
b) petroleum derived aromatic compounds	10%
c) compounds similar to b) with some changes in component ratios	2%
d) polar oxygenated organics containing carbonyl groupings with possible traces of organic phosphates	11%
e) column hold-up	3.5%

6) Gas Chromatography of Polarity Separated Fractions

The gas chromatograms obtained for fractions a-d supported the characterisation by infrared spectroscopy. Fraction b) showed one sharp peak in a general hydrocarbon envelope. No attempt was made to run the gas chromatogram of fraction e) because the system is set up for the characterisation of petroleum hydrocarbons and not for polar organics.

7) Total Potential and Leachable Phenol Content

An aliquot of the leachate well oil was extracted with 1% aqueous potassium hydroxide. This alkaline extract was analysed for phenol using the Gibbs method which gave a value of 70 mg/L. From this result, the original concentration of phenol in the oil was calculated:

Total potential phenol content: 291 mg/kg oil or
253 mg/L oil

In the determination of leachable phenol content, an aliquot of oil was mixed with distilled water and stirred by magnetic stirrer for 8 hours. Gibbs analysis for phenols gave a value of 6 ug/L in the diluted extract. From this, the original leachable phenol content of the sample can be calculated:

Leachable phenol content: 10 mg/kg oil of phenolics
8.6 mg/kg phenolics/L of oil

8) Gas Chromatographic Determination of Volatile Aromatic Hydrocarbons and Halogenated Components

This scan was carried out for the routine analysis of 38 organics (30 hydrocarbons and 8 widely used chlorinated solvents, see Table 1). The so-called headspace analysis was used where a known quantity of the sample in a sealed vial is heated in a thermostatically controlled bath at 85^{o} for 1 hour. A known volume of the headspace gases is injected into a gas chromatograph equipped with dual flame ionization and electron capture detectors. The former is sensitive to hydrocarbons and the latter to halogenated compounds.

In addition to 11 aliphatic hydrocarbons, 8 aromatic compounds and 5 chlorinated species were detected and quantitated. Concentrations of the significant aromatic and chlorinated compounds quoted below should be regarded as minimal levels owing to the oil substrate which will retain a considerable fraction of the volatiles even at elevated temperatures.

Compound	Estimated concentration (mg/L)
Benzene	22
Toluene	328
Ethylbenzene	236
p-Xylene	174
m-Xylene	383
o-Xylene	190
Cumene	7
Styrene	6
Methylene chloride	0.53
Carbon tetrachloride	0.03
Chloroform	0.01
Trichloroethylene	0.30
Tetrachloroethylene	0.09

9) Analysis for PCBs

Analyses for PCBs were carried out on this set of samples and two earlier samples collected from leachate well 5 in August and September, 1981.

The raw oil samples were extracted, cleaned-up on Florisil columns and analysed using electron capture gas chromatography. The chromatograms obtained demonstrated an excellent fit with Aroclor 1248, a commercial PCB mixture containing 48% chlorine. The levels detected in the oil samples were:

August 11, 1981	2,250 ppm (0.225%)
September 4, 1981	3,200 ppm (0.320%)
January 7, 1982	3,000 ppm (0.300%)

10) Analysis for Phosphate Esters

The oil sample of January 7, 1982, was separated by column chromatography and the various fractions screened by packed column gas chromatography, using a nitrogen/phosphorus specific detector. The presence of trialkyl, triaryl-alkyl and triaryl phosphates was indicated. Subsequent analyses by capillary column gas

chromatography using the element selective nitrogen/phosphorus detector confirmed the presence of tributyl phosphate and trichloroethyl phosphate in the sample. No tri(dichloropropyl) phosphate was detected nor were any other alkyl phosphate esters.

11) Gas Chromatographic/Mass Spectrometric Characterisation of Chromatographic Fractions

The leachate well oil sample was fractionated using a silica gel column. Five fractions were analysed by GC/MS for identification of the organic components. Two other fractions eluted with iso-octane were collected but contained significant amounts of oil and so were not suitable for trace organic analysis by GC/MS.

The five fractions analysed were as follows:

I Ether 0-50 mL
II Ether 50-100 mL
III Ether 100-150 mL
IV Methanol 0-50 mL
V Methanol 50-100 mL

Fraction I

This fraction contained mainly aromatic hydrocarbons. These aromatics were difficult to characterise as very little structural information was obtained other than a classification as aromatic hydrocarbons. This was based on the presence of ions which are characteristic of substituted benzene derivatives. In some cases molecular weight information was available and some could be defined (e.g. C_{18} benzene or C_{20} benzene derivatives) but the form of the aliphatic substituents was not clear.

In addition to these aromatics some chlorinated compounds were detected. These included tetrachlorophenol and PCBs with the Cl_3 to Cl_6 isomers being observed with a predominance of Cl_5 isomers.

Some methyl esters of benzoic acid derivatives were also detected along with some steroids such as cholestadiene.

Fraction II

The major components of this fraction were PCBs and phthalic acid esters. The PCBs included Cl_2 to Cl_9 isomers with Cl_4 isomers predominating. The phthalates included di-isooctyl phthalate, benzylbutyl phthalate and diethyl phthalate plus many others whose structure could not be easily determined. Two phosphate esters were also observed - these were octyldiphenyl phosphate, tri-2,4-xylyl phosphate.

In addition to these a number of aromatic hydrocarbons were observed. In this fraction the more volatile compounds were observed and so their structures could be determined with more certainty. They included the following:

Substituted benzenes - C_4 and C_5
Naphthalene
Methyl naphthalenes
Dimethyl naphthalenes
Trimethyl naphthalenes
Phenanthrene
Dimethyl phenanthrene
Methoxy biphenyl
Substituted dihydroindene

Some miscellaneous compounds were also observed including phenol derivatives (BHT, octyl phenol), a ketone, and esters of long chain fatty acids.

Fraction III

This fraction contained far fewer components than fractions I and II and at lower concentrations. The major components were tributyl phosphate and di-isooctyl phthalate. Most other components were also esters including other phthalates (dibutyl, benzyl butyl and others) and octyl diphenyl phosphate. There were, in addition, several silicone compounds and two steroid-like compounds.

Fraction IV

The major components of this fraction were long chain fatty acids such as stearic and palmitic acids, methyl stearate and tributyl phosphate. Lower concentrations of other methyl esters of long chain fatty acids were also observed together with an aldehyde, some alcohols and a polyethylene glycol derivative.

Fraction V

This fraction consisted mainly of esters. The major component was di-isooctyl phthalate. A number of methyl esters of fatty acids were also observed, some of these also being major components. Lower concentrations of a number of other phthalates such as dimethyl and butyl methyl were also observed as well as low concentrations of aliphatic hydrocarbons and silicone compounds.

IV ANALYSIS OF OBSERVATION WELLS

This section of the report gives an account of the analytical work and findings on three observation wells on the landfill site. The analytical data tables (2-8) are included in Appendix A at the end of this report. The observation wells were sampled in January 1982, specifically for this study, and supplemental data for metal analyses have been added from the regular quarterly monitoring survey, November 1981.

A. ANALYTICAL METHODS

All well samples were analysed for general water quality parameters and metals (see Appendix B for method descriptions). The analytical investigation for trace organics included the following scans and techniques:

1) Volatile Organohalide Scan

This scan is calibrated for measuring the six most frequently occurring organohalides: chloroform, carbon tetrachloride, trichloroethylene, dichlorobromomethane, tetrachloroethylene and dibromochloromethane, with detection limits of 0.1-2 ug/L.

2) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

3) Gas Chromatographic/Mass Spectrometric Scans for Extractable Organics

Extractions are carried out under strongly alkaline and then acidic conditions to furnish "base neutral" and "acidic" fractions, respectively. The analytical sensitivity of this scan was increased five-fold over standard procedures by the injection of a correspondingly larger aliquot.

The following is a description of the analytical procedures used in GC/MS analysis:

a) Sample Concentration

In order to carry out GC/MS analysis of trace organic compounds one has to concentrate the organics present in the sample in a suitable solvent. If volatile organics are required the concentration is done by purging the compounds from the

sample with a stream of nitrogen and trapping them onto an adsorbent material. The trap is then heated rapidly in the presence of a stream of inert gas and the organics are introduced into the instrument. For the less volatile organics this is carried out by an extraction procedure into methylene chloride as solvent. Prior to the purging and extraction procedure an internal standard is added to the sample. This internal standard is chosen as a compound which is unlikely to appear in any environmental sample. The purpose of its addition is to monitor that the purging and extraction has occurred successfully and that the conditions of the GC/MS analysis have not changed markedly. In addition the standard acts as an indicator for quantitative purposes, since we add a known amount to each sample.

b) Analysis

After extraction, a portion of the sample concentrate is introduced to the GC/MS instrument. The gas chromatograph acts to separate the components of a complex mixture on the basis of the speed with which different compounds are able to pass through the column. Over a period of time, as each compound (or group of compounds) exits from the column it is presented to the mass spectrometer. The molecules of the separated compounds are then broken up in the mass spectrometer to give ionised fragments. These fragments give a pattern characteristic of a particular compound or class of compounds. These patterns, called mass spectra, are stored in a computer together with the time during the analysis when they appeared.

c) Interpretation

Interpretation of the mass spectra obtained has to be undertaken in order to identify the components present. In addition GC/MS is a useful tool for determining whether particular compounds or groups of compounds are present in a sample. Because each compound elutes from the column at a certain time and fragments in a characteristic way, one can search the data collected and if specific fragments or indicators are not found at the right time, it is concluded that the compound is not present.

The identification of the compounds which produce a particular fingerprint of ionised fragments is a much more difficult task. A number of factors need to be considered including:

(i) Time of elution

(ii) The possibility of a mixture of compounds with quite different chemical characteristics appearing at the same time and yielding confused spectra.

(iii) Different compounds with the same elution time may give quite similar spectra.

(iv) The possibility that the fragments seen can be reconstructed to yield compounds which are naturally occurring or are introduced by normal human activity, by the sampling or by the analytical process as opposed to compounds of definite industrial origin.

The computer can assist in the interpretation by carrying out a comparison of the "unknown" to mass spectra of over 25,000 compounds stored in the computer library. In a very complex sample, manual interpretation has to be carried out by a skilled mass spectrometrist. This interpretation is based on the analysis of the mass spectrum obtained by the instrument together with a knowledge of organic and environmental chemistry. The manual interpretation is usually done with reference to the library of over 25,000 compounds in the computer and to reference documents listing mass spectra obtained in other laboratories.

When a computer library search is carried out the normal requirements for an identification are a computer "fit" of greater than 80% with the library mass spectrum. On occasion, the mass spectra of a chemical class of compounds show general similarities and it is difficult to distinguish the members of that class. Such is the case when one considers aliphatic hydrocarbons.

The certainty of identification in most cases is based mainly on the inspection of the mass spectra. The presence of certain classes of compounds which may be hazardous, such as those containing chlorine atoms, can be ruled out by this inspection. Little other comparative analytical data is available for evaluation because of the wide variety of compounds observed by this technique and the lack of background data. In order to increase the degree of confidence in the identification, an authentic standard must be analysed under identical analytical conditions. Many of the compounds identified as trace organics in environmental samples are not in fact available commercially as pure compounds suitable for use as standards.

This manner of interpretation is an accepted approach and is classified as Level II in terms of confidence level in a document entitled "Master Scheme for the Analysis of Organic Compounds in Water - Interim Protocols" prepared by Analytical Sciences Division, Chemistry and Life Sciences Group, Research Triangle Institute for the U.S. E.P.A.

In the case of samples received from Whitchurch-Stouffville, an attempt has been made to make the methodology five times more sensitive than our normal analytical conditions and we are therefore looking at ultratrace amounts. This extra sensitivity provides the capability of detecting components which interfere in the method and which are not normally detected. It also makes the mass spectra more difficult to interpret because of the small amount of component present in the sample; the certainty of identification is therefore reduced. Interpretations of spectra from very low concentrations of material are also made more difficult by background interference.

The mass spectrometric response can be used for quantitative purposes as well as qualitative interpretation. This quantitation, however, is accurate only when authentic standards of the components identified can be analysed through the total analytical process. As described above there are difficulties in obtaining many of these compounds. In the analysis of volatile organics the number of compounds which can be detected is more limited and consequently standards for a group of 23 volatile organics are routinely analysed for quantitative purposes. In the analysis of extractable organics the range of compounds to be considered is very extensive and a different, qualitative approach is taken. An estimate of the quantity of a component present in a sample can be made based on the response (ion current) of the compound compared to that of the internal standard. Some basic assumptions have to be made, which render the quantitation, an estimate. The main assumptions made are:

(i) The recovery of the compound in the concentration process is identical to that of the internal standard.

(ii) The mass spectrometric response of the compound is identical to that of the internal standard.

(iii) The GC/MS response has a linear relationship to concentration.

These assumptions may not be completely valid so only a semi-quantitative figure can be given.

The "Master Scheme for the Analysis of Organic Compounds in Water - Interim Protocols" suggests a detection limit of 5 ppb or 2 ppb (depending on technique) for extractable organics in surface waters. In the approach used for this study an attempt has been made to improve sensitivity to less than 0.5 ppb in order to better characterise the low levels of compounds present in these samples.

4) Other class-specific scans were included for 7 chlorophenoxy acid herbicides, 8 triazine herbicides, 14 chlorinated benzenes and related compounds, 6 chlorophenols, 21 organochlorine pesticides and PCBs, 11 trialky-triarylphosphates and 13 organophosphate pesticides. Details on these scans are given in Appendix B.

B. ANALYTICAL RESULTS

The analysis of observation wells, and the identification of organic substances present there, is useful in the evaluation of on-site groundwater contamination and in establishing possible contamination of private wells by chemicals of landfill site origin.

During the sampling of these observation wells for trace organics, the field samplers used organic solvents (hexane/acetone) when cleaning sampling equipment between the sampling of different wells. As GC/MS analysis is optimised for trace levels of volatile organics, these components became major contaminants in the sample. The following preliminary results have therefore ignored the presence of acetone and hexane isomers in the samples in order to allow the proper interpretation of GC/MS data.

The interpretation and linking of the data on extractable organics from the three observation wells showed different chemical profiles but also a number of phosphate esters, phthalate esters and benzamide derivatives which were common to all three observation wells. An investigation of the potential source of these compounds led to the analysis of a leachate of the gloves used during the sampling (which took place during the winter months). The above organic compounds were found to originate from the gloves and have consequently been omitted from the analytical results (see Table 8).

The chromatographic priority pollutant analytical approach (see page 25) was not found suitable because of the complexity of mixtures of organics in these wells. These samples were analysed by the Gas Chromatography/Mass Spectrometry (GC/MS) technique for volatile and extractable organics, and were also analysed for PCBs and trace metals.

1) Observation Well 2-75

a) PCBs, Organochlorine Pesticides and other Class-Specific Scans

The observation well water was tested for PCBs and 21 organochlorine pesticides and none were detected (Table 5). Other class-specific scans were included as described on page 15. The only trace organic detected in OW 2-75 by these scans was pentachlorophenol, which was present at 0.06 ug/L in the unfiltered sample and 0.1 ug/L in the filtered sample (Tables 4 to 8).

b) Scan for Trace Metals (filtered)

Metals	Concentration mg/L	Detection Limit mg/L
Arsenic	nd	0.001
Cadmium	0.002	0.0002
Chromium	0.004	0.001
Copper	0.045	0.001
Lead	0.004	0.003
Nickel	0.006	0.001
Zinc	0.12	0.001

Data on general water quality parameters and levels for other metals are included in Tables 2 and 3.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

This well contained only two volatile organics above the 1 ug/L level: isopropanol at 2.8 ug/L and methylethyl ketone at 1.2 ug/L.

A number of organics were identified at less than 1 ug/L levels:

Compound	Concentration ug/L
Chloroform	0.1
Benzene	below 0.1
Toluene	0.1
*Diethyl ether	0.8#
*Tetrahydrofuran	0.2#
*Methyl-isobutyl ketone	0.6#
*Methylpentanol	0.2#
*Naphthalene	0.2#

estimated concentrations, standards not analysed

* identifies bulk industrial organics of wide application

d) Gas Chromatographic/Mass Spectrometric Scan For Extractable Organics

No organic compound was found at levels above 1 ug/L. At less than 1 ug/L levels, the following were identified or characterised:

0.5 - 1.0 ug/L:	* Octanoic acid
0.1 - 0.5 ug/L:	Molecular sulphur
below 0.1 ug/L:	Aromatic carboxylic acids (5)
	Unidentified carboxylic acids (3)
	* 4-Butoxybutyric acid
	Cyclohexenecarboxylic acid derivative
	Unidentified alcohols (2)
	Dimethyloctenol
	Aliphatic and alicyclic hydrocarbons (12)
	* Pentachlorophenol
	Unidentified (2)
	Methyl esters (2)
	* Butyl cellosolve methyl ether
	* Ethyl cellosolve
	Other cellosolve derivatives (3)
	Pentaoxapentadecane

* identifies bulk industrial organics of wide application

2) Observation Well 16-70

a) PCBs, Organochlorine Pesticides and other Class-Specific Scans

From the class-specific scans for trace organics (Tables 4 to 8), the following compounds were detected:

Compound	Filtered Sample	Unfiltered Sample
Beta BHC	2 ng/L	4 ng/L
Gamma BHC (Lindane)	nd	1 ng/L
PCBs	nd	25 ng/L
Pentachlorophenol	0.3 ug/L	0.2 ug/L

b) Scan for Trace Metals (filtered)

Metals	Concentration mg/L	Detection Limit mg/L
Arsenic	nd	0.001
Cadmium	0.003	0.0002
Chromium	0.004	0.001
Copper	0.031	0.001
Lead	0.010	0.003
Nickel	0.006	0.001
Zinc	0.16	0.001

Data on general water quality parameters and levels of other metals are included in Tables 2 and 3.

c) Gas Chromatographic/Mass Spectrometric Analysis for Volatile Organics

This well contained only one volatile organic compound above the 1 ug/L level:

Toluene 1.4 ug/L

A number of other organics were identified at less than 1 ug/L levels:

Compound	Concentration ug/L
Chloroform	below 0.1
Isopropanol	0.6#
Diethyl ether	0.6#
Aliphatic hydrocarbons (4)	0.1 - 0.3#

estimated concentrations, standards not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis For Extractable Organics

Compounds characterised or identified at above 1 ug/L levels were:

Aliphatic hydrocarbons (16 at 1-3 ug/L individual concentrations)
Carboxylic acids (2 at 2 ug/L)
*Di-secondary butyl azelaate (4 ug/L)
Steroid (1 ug/L)

At 0.5 - 1.0 ug/L levels:

Aliphatic hydrocarbons (13)
#Dimethylphenanthrene
#Condensed-ring aromatic hydrocarbon (M.W. 202)
Aliphatic alcohol
Aliphatic methyl ester
* Benzyl-butyl-phthalate
6-Acetyl-2,5-dihydroxy-1,4-naphthoquinone
Steroid

At 0.25 - 0.5 ug/L levels:

Aliphatic hydrocarbons (11)
#Benzo(k)fluoranthene (or isomer)
#Methylphenanthrene (2 isomers)
Dodecyl-perhydro phenanthrene
Steroid
Alcohols (3)
* Butylated hydroxytoluene (BHT)
#Methyldibenzothiophene
Sulphur containing (possibly Pentathiepane)

At 0.1 - 0.25 ug/L levels:

Aliphatic hydrocarbons (10)
#Methylphenanthrene
#1,6-Dimethyl-4-isopropylnaphthalene
#Dimethyl-isopropyl-decahydronaphthalene
Steroid
Cholestane
Cholesta-3,5-dien-7-one
Cholesta-3,5-diene
Alcohols (4)
Carboxylic acid
* Butyl stearate
* N-Methylbenzamide

Below 0.1 ug/L:

Aliphatic hydrocarbons (36)
Aliphatic ketone
#7H-Indeno-2,1-anthracen-7-one
#2,5-Diacetyl-6-methoxybenzofuran
* Methyl palmitate
Methyl ester of carboxylic acid
* Butyl butyrate
* Isopropyl benzoate
Compound containing 1 chlorine atom (M.W. 304)

* identifies bulk industrial organics of wide application
\# indicates coal tar or spent crank-case oil origin

3) Observation Well 1-80

a) PCBs, Organochlorine Pesticides and other Class-Specific Scans

As for the other observation wells, OW 1-80 was analysed for trace organics by class-specific scans (Tables 4 to 8). Pentachlorophenol was detected at 4.4 ppb in the unfiltered sample and 3.4 ppb in the filtered sample.

b) Scan for Trace Metals (filtered)

Metals	Concentration (mg/L)	Detection Limit (mg/L)
Arsenic	0.001	0.001
Cadmium	0.0004 (unfilt.)	0.0002
Chromium	0.010	0.001
Copper	0.018	0.001
Lead	nd	0.003
Nickel	0.032	0.001
Zinc	0.33	0.001

Data on general water quality parameters and levels for other metals and extractable organics are included in Tables 2 and 3.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

The following compounds were identified:

Compound	Concentration (ug/L)
*1,1-Dichloroethane	2.1
*Chloroform	0.1
*1,2-Dichloroethane	0.7
Trichloroethylene	0.2
Benzene	1.4
Toluene	0.9
Ethylbenzene	present, not quantitated
o- + p-Xylenes	2.6
*trans-1,2-Dichloroethylene	2.0
*Diethyl ether	3.7#
*Methyl ethyl ketone	0.4#
Hydrocarbons C_7H_{16} isomers (4), total	5.8#
Hydrocarbons C_9H_{12} isomers (2), total	5.5#
Hydrocarbon $C_{10}H_{20}$ isomer	81.9#
*Methylstyrene	1.1#

estimated concentrations, standards not analysed
* identifies bulk industrial organics of wide application

d) Gas Chromatographic/Mass Spectrometric Scan for Extractable Organics

The following compounds were identified or characterised at concentrations of 10 ug/L or greater:

Compound	Estimated Concentration (ug/L)
* Dihydroisophorone	200
* Isophorone	22
* Isophorone isomer	40
* Menthol	17
* Carvomenthol	13
* Isopropyl benzoate	15
* Diethylpentylphosphate	40
Methyl esters of substituted cyclohexene-1-carboxylic acids (2)	40 + 12
* Pentachlorophenol	30
* Xylenol	30
* Ethylcarbitol ethyl ether	50
* Polyethyleneglycol derivatives	150
* Toluenesulphonamide	50
* Fenchone	25
Steroid	15
* 3-Methyl-2,6-dioxo-4-hexenoic acid	20
Aliphatic hydrocarbons (3), total	34
Polyglycol derivative	10
Unidentified	30
Molecular sulphur	10

At 1-9 ug/L levels:

Octanedione	9
Tetrahydro-hexamethyl-s-indacene-1,7-dione	9
Aliphatic aldehydes and ketones (3), total	5
Dimethyloctalone	6
1-Benzoyl-1-sec. butylacetone	3
* Propyleneglycol	9
Resin acid	4
* 4-Butoxybutanoic acid	2
Aliphatic alcohols (2)	3 + 4
Aliphatic and alicyclic hydrocarbons (10), total	69
Ethyl ester of a C_5 carboxylic acid	2
* Camphor	8
4-Hydroxyoctalone	1
3-(3-Dimethylamino)-2-propenylidene-2(3H) benzofuranone	3
Unidentified aliphatic alcohol	1
Unidentified polyglycol derivatives (2), total	11
Unidentified component	1
2-Propenylbenzoate	2
* S-Methylthioanisoate	1

At 0.5 - 1 ug/L levels:

6-Methyl-6-azobicyclo(3,2,1)octan-3-one
Dimethylphthalic anhydride
Unidentified aldehyde/ketone
Propenylidene-2(3H)-benzofuranone-cyclohexanone derivative
Dimethylbenzoic acid
*p-t-Butylbenzoic acid
Alicyclic hydrocarbon
Methyl ester of carboxylic acid
Unidentified glycol derivatives (3)
2-Hexyl-1 methyl-Pyrrolidine
*Toluenesulphonamide

At 0.1 - 0.4 ug/L levels:

*Phthalic anhydride
Unidentified aldehyde/ketone
*5-Ethyl-dihydro-5-phenyl-4,6(1H, 5H)pyrimidinedione (Primidone)
4-(1-hydroxy-1-isopropyl)acetophenone
Carboxylic acid (octanoic)
Aromatic carboxylic acids (3)
Unidentified alcohol
Aliphatic and alicyclic hydrocarbons (9)
Unidentified esters of carboxylic acids (4)
Unidentified glycol

* identifies bulk industrial organics of wide application

V. ANALYSIS OF PRIVATE WELLS

A. ANALYTICAL METHODS

The analytical methods described in section IV A (see pages 11 to 15) were also applied in the analysis of the six private, off-site wells. In addition, the newly developed priority pollutant scan and a class-specific scan for tetrachlorodibenzo-p-dioxins were applied to these samples. The priority pollutant scan is based on high resolution dual capillary column gas chromatography for 80 organic compounds most commonly occuring in toxic industrial wastes. Also included are analyses for PCBs, organochlorine pesticides and trace metals. Each private off-site well was sampled twice for bacterial indicator parameters and for general nuisance organisms.

For each of the wells, a single sample was analysed, and at the very low concentrations estimated on some of the extractable compounds observed, positive identifications were difficult to achieve. Because of this, many are tentative identifications. Some of the organics identified could be confirmed by the use of XAD resin concentrates from larger sample volumes for all of the private wells except Ballantrae Plaza. This concentration procedure was adapted from that used for the Ames testing protocol and, despite not being optimised for GC/MS, some useful information was available.

The analytical scheme and compounds included in the scans are described in detail in Section B for Ballantrae Plaza. Unless otherwise indicated, the same analyses were applied to each of the other five private, off-site well samples.

In order to provide an independent data base for comparison purposes, samples from the Hutchinson and Ballantrae Plaza wells were sent to Mann Testing Laboratories, a private independent laboratory, for corroborative testing by GC/MS. Their findings, included as Appendix D, supported the results described in this report.

Further chemical analysis was performed by Ontario Research Foundation on samples from the Hutchinson and M.N.R. wells. This study involved concentration, fractionation and size exclusion HPLC analysis and indicated that the high molecular weight compounds found were similar to those in other Ontario drinking water supplies. The results are described in detail in Appendix E.

B. ANALYTICAL RESULTS - PRIVATE WELLS

1) Trace Organic Analysis

BALLANTRAE PLAZA WELL

a) Priority Pollutant Scan

This scan (Table 17) did not detect the presence of any of the 80 compounds listed below or indicate the presence of unknown components in the well water. The detection limits for these compounds generally ranged from 0.5 - 5 ug/L.

Volatiles

1. 1,1-Dichloroethylene
2. Dichloromethane
3. t-1,2-Dichloroethylene
4. 1,1-Dichloroethane
5. Chloroform
6. 1,1,1-Trichloroethane
7. 1,2-Dichloroethane
8. Carbon tetrachloride
9. Benzene
10. 1,2-Dichloropropane
11. Trichloroethylene
12. Bromodichloromethane
13. Toluene
14. 1,1,2-Trichloroethane
15. Dibromochloromethane
16. Tetrachloroethylene
17. Chlorobenzene
18. Ethylbenzene
19. m + p-Xylene
20. Bromoform
21. o-Xylene
22. 1,1,2,2-Tetrachloroethane
23. 1,4-Dichlorobenzene
24. 1,3-Dichlorobenzene
25. 1,2-Dichlorobenzene

Base/Neutrals

26. Hexachloroethane
27. Hexachlorobutadiene
28. Hexachlorobenzene
29. 1,2,4-Trichlorobenzene
30. Bis-(2-chloroethoxy)methane
31. Naphthalene
32. 2-Chloronaphthalene
33. Nitrobenzene
34. 2,4-Dinitrotoluene
35. 2,6-Dinitrotoluene
36. 4-Bromophenyl phenyl ether
37. Bis-(2-Ethylhexyl) phthalate
38. Di-n-octyl phthalate
39. Di-methyl phthalate
40. Di-ethyl phthalate
41. Di-n-butyl phthalate
42. Butyl benzyl phthalate
43. Acenaphthylene
44. Acenaphthene
45. Fluorene
46. Fluoranthene
47. Chrysene
48. Pyrene
49. Phenanthrene
50. Anthracene
51. Benzo(a)anthracene
52. Dibenzo(a,h)anthracene
53. Benzo(b)fluoranthene
54. Benzo(a)pyrene
55. Benzo(g,h,i)perylene
56. 4-Chlorophenyl phenyl ether
57. 1,2-Diphenyl hydrazine
58. Hexachlorocyclopentadiene
59. N-Nitroso-diphenylamine
60. N-Nitroso-dimethylamine
61. N-Nitroso-di-n-Propylamine
62. Caffeine
63. Nitrobenzene
64. Butoxyethoxyethanol
65. Cholesterol
66. p-Chloroaniline
67. Benzothiazole
68. Benzo(k)fluoranthene

Acids

69. Hexadecanoic Acid
70. Phenol
71. 2-Nitrophenol
72. 4-Nitrophenol
73. 2,4-Dinitrophenol
74. 4,6-Dinitro-o-Cresol
75. p-Chloro-m-Cresol
76. 2-Chlorophenol
77. 2,4-Dichlorophenol
78. 2,4,6-Trichlorophenol
79. 2,4-Dimethylphenol
80. Pentachlorophenol

A scan for PCBs and 21 organochlorine pesticides (Table 12) was also negative. This scan includes the following compounds with detection limits between 1-5 ppt (ng/L) except for PCBs (20 ng/L):

Organochlorine Pesticides

1.	Hexachlorobenzene	12.	pp'DDE
2.	Alpha BHC	13.	pp'DDD
3.	Beta BHC	14.	op'DDT
4.	Gamma BHC (Lindane)	15.	pp'DDT
5.	Heptachlor	16.	Methoxy Chlor (DMDT)
6.	Heptachlor Epoxide	17.	Mirex
7.	Aldrin	18.	Thiodan I
8.	Dieldrin	19.	Thiodan II
9.	Endrin	20.	Thiodan Sulphate
10.	Alpha Chlordane	21.	Oxychlordane
11.	Gamma Chlordane	22.	PCBs

The scan for the following trace metals is included in the priority pollutant scan.

Metal	Concentration (mg/L)	Detection Limit (mg/L#)
Arsenic	nd	0.001
Cadmium	nd	0.0001
Chromium	0.002	0.001
Copper	0.033	0.001
Lead	0.005	0.002
Mercury	nd	0.01
Nickel	0.002	0.001
Zinc	0.020	0.001

except for mercury (ug/L)

The results are well within the Ministry's criteria for drinking water and are comparable to results from other drinking waters in the province. Data on general water quality parameters, microbiological analyses and other metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

The volatile organohalide scan did not show the presence of any of the listed compounds (Table 13).

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

All the compounds listed below are specifically quantitated in this scan. In addition, many other compounds in this class would be identified by GC/MS if they were present.

Volatile Organics

1. Methylene chloride
2. 1,1-Dichloroethane
3. Chloroform
4. 1,2-Dichloroethane
5. 1,1,1-Trichloroethane
6. Carbon tetrachloride
7. Dichlorobromomethane
8. 1,2-Dichloropropane
9. Trichloroethylene
10. Chlorodibromomethane
11. Benzene
12. 1,3-Dichlorobutane#
13. Bromoform
14. Tetrachloroethylene
15. Toluene
16. Chlorobenzene
17. Ethylbenzene
18. m-Xylene
19. o- or p-Xylene
20. 1,1-Dichloroethylene
21. 1,1,2-Trichloroethane
22. 1,1,2,2-Tetrachloroethane
23. 1,2-Dichlorobenzene
24. p-Chlorotrifluorotoluene

internal standard

This scan, with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5 ug/L), identified no components at concentrations greater than 1 ug/L. A number of components were detected at sub-ppb levels. These are:

Compound	Concentration (ug/L)
1,1,1-Trichloroethane	0.1
Toluene	0.4
Ethylbenzene	0.2
m-Xylene	0.3
o- or p-Xylene	0.3
Chloroform	below 0.1
Methyl isobutyl ketone	0.1#
a C_3 alkylbenzene	0.1#

estimated concentrations, standards not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This was carried out with both base-neutral and acid extracts with the following results:

Only three compounds were identified at levels estimated at about 1 ug/L (ppb). These were a gallic acid derivative (trimethoxybenzene), an unidentified

non-chlorinated (see page 13) component which was possibly an aliphatic hydrocarbon and a thioacetic acid derivative. The first compound could be of plant origin, possibly from natural tannins and lignins. The latter compound together with a similar compound seen at lower concentrations could be produced by sulphate-reducing bacteria or associated micro-organisms.

Partly because of the five-fold increase in analytical sensitivity employed for these samples, a range of organic compounds were observed at levels estimated at below the 1 ug/L concentration, many below the 0.1 ug/L levels. At these ultra-trace levels absolute identification of unknown individual organics becomes increasingly difficult. Many of the ultra-trace organics found in the Ballantrae Plaza well may have been derived from natural sources or may have resulted from human habitation.

The range of compounds found at an estimated concentration below the 1 ppb level were characterised as:

esters of fatty acids
alcohols
aliphatic aldehydes and alicyclic alcohols
caffeine derivatives
aldehydes and ketones

A number of compounds were tentatively identified at sub-ppb levels and could not be directly associated with natural sources. Due to the low concentrations, good mass spectra could not be obtained and positive identification was not possible. These compounds are:

Benzopyrene
Polycyclic aromatic ketones (2)
Dibenzyl
Naphthylamine
Amide derivatives (2)
Resorcyl aldehyde derivative

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16. These scans, comprising 60 compounds, were negative.

HUTCHINSON WELL

a) Priority Pollutant Scan

The priority pollutant scan (Table 18) did not detect the presence of any of the 80 compounds listed at the specified detection limits or indicate the presence of unknown compounds in the well water.

A scan for PCBs and 21 organochlorine pesticides was also negative (see Table 12).

Trace metals were detected at levels well below the Ministry's criteria and at levels expected in drinking water in the province. Data on general water quality parameters, microbiological analyses and other metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

This scan did not show the presence of any of the compounds listed in Table 16.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

The list of organics quantitated in this scan is shown on page 28. This scan with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5 ug/L) identified no components at concentrations greater than 1 ug/L. The following compounds were identified at less than 1 ug/L levels:

Compound	Concentration (ug/L)
Chloroform	0.1
Toluene	0.2
Ethylbenzene	below 0.1
m-Xylene	below 0.1
o + p-Xylene	below 0.1
Diethyl ether	below 0.1#

estimated concentration, standard not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This analysis was carried out on both base-neutral and acid extracts on a 1 litre sample. After correcting for laboratory background levels, an aliphatic alcohol was detected at an estimated level of 1 ug/L, with a second alcohol present at between 0.5 and 1 ug/L.

The five-fold increase in analytical sensitivity achieved in the analysis of this sample enabled a range of compounds to be identified or characterised at sub-ppb levels. Many of these compounds such as the alcohols mentioned above could be derived from natural sources and human habitation. At these ultratrace levels it becomes increasingly difficult to identify an individual organic component on the basis of its mass spectrum but it is often possible to assign a compound to a specific chemical class. For this well a single sample was analysed, collected at a certain point in time. At the very low concentrations observed on some of the extractable compounds seen, positive identifications were difficult to achieve and therefore many are tentative identifications.

The range of compounds at below 1 ppb levels in the Hutchinson well were characterised as:

steroids
aliphatic alcohols
aliphatic hydrocarbons
aliphatic ketones and aldehydes
food preservatives
tri(dichloropropyl)phosphate

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16. These scans, comprising 60 compounds, were negative with the exception of the detection of an ester of phosphoric acid, tri(dichloropropyl) phosphate (Table 16). This chloroalkyl phosphate has been used in the past as a flame retardant in mattresses and other household items.

In an attempt to confirm this finding and to increase the sensitivity, a separate 4 litre water sample (usual volume is 1 litre) was extracted under neutral conditions. This extract was also subjected to GC/MS analysis for organic extractables. As before, but in greater number, similar classes of compounds were

observed. The presence of tri(dichloropropyl) phosphate was confirmed, again at sub-ppb levels. This phosphate ester was different from those detected in the observation wells.

GC/MS analysis on an XAD resin concentrate of a 20 litre sample confirmed the presence of tri(dichloropropyl)phosphate, cholesterol and another steroid.

M.N.R. WELL

a) Priority Pollutant Scan

The priority pollutant scan (Table 19) did not detect the presence of any of the 80 compounds listed at the specified detection limits except for traces of two phthalates thought to be due to sample rather than well contamination. The scan did not indicate the presence of unknown compounds in the well water.

Scans for PCBs and 21 organochlorine pesticides were also negative (see Table 12).

Trace metals in the priority pollutant scan were found at levels well within the Ministry's criteria for drinking water and are comparable to results from other drinking waters in the province. Data on general water quality parameters, microbiological analyses and other metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

This scan did not show the presence of any volatile organohalides as listed in Table 13.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

This scan with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5. ug/L) identified no components at concentrations greater than 1 ug/L. The following compounds were identified at less than 1 ug/L levels:

Compound	Concentration (ug/L)
Toluene	0.1
m-Xylene	below 0.1
o- and p-xylene	below 0.1
Hexane	below 0.1 #
Methylisobutylketone	below 0.1 #

estimated concentrations, standard not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This analysis was carried out on both base-neutral and acid extracts on a 1 litre sample. After correcting for laboratory background levels, no compounds were detected above 1 ug/L.

The five-fold increase in analytical sensitivity achieved in the analysis of this sample enabled a range of compounds to be identified or characterised at less than 1 ug/L levels. Many of these compounds could be derived from natural sources and human habitation.

The range of compounds at less than 1 ug/L levels in the MNR well were characterised as:

Steroids
Aliphatic alcohols
Aliphatic hydrocarbons
Aliphatic aldehydes and ketones
Aliphatic carboxylic acids and esters
Esters of phthalic acid
Derivative of polyethylene glycol
Methyl-styrene
C_4-benzene derivative
Sulfur containing compound
Nitrogen containing compounds

Methyl styrene found in this well may have been derived from plastic materials.

The use of the XAD 20 litre extract confirmed only the presence of 3 steroids estimated at 0.1 - 0.25 ug/L in this sample.

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16.

FOCKLER WELL

a) Priority Pollutant Scan

The priority pollutant scan (Table 20) did not show the presence of any of the 80 compounds listed at the specific detection limits (other than a trace of a phthalate thought to be due to contamination) or indicate the presence of unknown compounds in the well water.

A scan for PCBs and 21 organochlorine pesticides was also negative (see Table 12).

Trace metals in the priority pollutant scan, where detected, were at levels well below the Ministry's criteria and at levels expected in drinking water in Ontario. Data on general water quality parameters, microbiological analyses and other metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

This scan did not show the presence of any of the compounds listed in Table 13.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

This scan with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5 ug/L) identified no components at concentrations greater than 1 ug/L. The following compounds were identified at less than 1 ug/L levels:

Compound	Concentration (ug/L)
Chloroform	below 0.1
Benzene	below 0.1
Toluene	0.3
Ethylbenzene	below 0.1
m-xylene	0.2
o- and p-xylene	0.1
Acetone	0.4 #
Methylethyl ketone	0.1 #
Styrene	0.1 #
a C_9H_{12}	0.1 #

estimated concentration, standard not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This analysis was carried out on both base-neutral and acid extracts on a 1 litre sample. After correcting for laboratory background levels, no compounds were detected above approximately 0.25 ug/L.

The five-fold increase in analytical sensitivity achieved in the analysis of this sample enabled a range of compounds to be identified or characterised at less than 1 ug/L levels. Many of these compounds could be derived from natural sources and human habitation.

The range of compounds at below 0.25 ug/L levels in the Fockler well were characterised as:

steroids
aliphatic alcohols
aliphatic and alicyclic hydrocarbons
esters of carboxylic acids
food preservatives and their oxidation products
Diethyl phthalate

As with the other private well samples, an XAD resin cartridge (also used for Ames testing) containing the organics trapped from 20 litre of water was eluted with methylene chloride to remove the organics, and the eluate was then concentrated. The use of the 20 litre extract for this sample confirmed only the presence of diethyl phthalate, present at below 0.1 ug/L.

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16.

TRANMER WELL

a) Priority Pollutant Scan

The priority pollutant scan (Table 21) did not detect the presence of any of the 80 compounds listed at the specific detection limits or indicate the presence of unknown compounds in the well water.

A scan for PCBs and 21 organochlorine pesticides was also negative (Table 12).

Trace metals were detected at levels well below the Ministry's criteria and at levels expected in drinking water in Ontario. Data on general water quality parameters, microbiological analyses and levels of metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

This scan did not show the presence of any of the compounds listed in Table 13.

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

This scan with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5 ug/L) identified no components.

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This analysis was carried out on both base-neutral and acid extracts on a 1 litre sample. After correcting for laboratory background levels, no compounds were detected above 1 ug/L.

The five-fold increase in analytical sensitivity achieved in the analysis of this sample enabled a range of compounds to be identified or characterised at sub-ppb levels. Many of these compounds could be derived from natural sources and human habitation.

The range of compounds at below 1 ug/L levels in the Tranmer well were characterised as:

steroids
aliphatic alcohols
* aliphatic hydrocarbons
aliphatic carboxylic acids
* aliphatic carboxylic esters
* polyethylene glycol derivatives
common plasticizers
Nicotine
PAHs
* aliphatic amides
oxidation product of food preservative
terpenoid-type compound

The presence of both nicotine and PAH may be linked by their normal presence in tobacco products and smoke. Few components were confirmed by the resin extract technique using a 50 L concentrate. The ones that were are marked with an asterisk(*) above.

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16.

COUGHLAN WELL

a) Priority Pollutant Scan

The priority pollutant scan (Table 22) showed the presence of dichloromethane at above the detection limit but no other compounds on the list were observed.

A scan for PCBs and 21 organochlorine pesticides was also negative (see Table 12).

Trace metals in this scan were detected at levels below the Ministry's criteria and at levels expected in private drinking water supplies in Ontario. Data on general water quality parameters, microbiological analyses and other metals are included in Tables 9 to 11.

b) Volatile Organohalide Scan

This scan did not show the presence of any of the listed compounds (Table 13).

c) Gas Chromatographic/Mass Spectrometric Scan for Volatile Organics

This scan with detection limits of 0.05 ug/L for all 24 components except methylene chloride (5 ug/L) identified no components at concentrations greater than 1 ug/L. A number of components were seen at levels less than 1 ug/L:

Compound	Concentration (ug/L)
Toluene	0.3
Ethylbenzene	below 0.1
m-xylene	0.1
o- or p-xylene	0.1
a C_7H_{16} (2 isomers)	0.2 total #
Styrene	below 0.1 #

estimated concentrations, standards not analysed

d) Gas Chromatographic/Mass Spectrometric Analysis for Extractable Organics

This analysis was carried out on both base-neutral and acid extracts on a 1 litre sample. After correcting for laboratory background levels, only two com pounds were identified at levels estimated at above 1 ug/L. These were an aliphatic amide (1 ug/L) and dimethylbenzylamine (3 ug/L). The latter could be derived from quarternary ammonium based fabric softeners, surfactants or germicides. The aliphatic amide may be from the same source.

Partly because of a five-fold increase in analytical sensitivity employed for these samples, a range of organic compounds were observed at levels estimated at below the 1 ug/L concentration, many below the 0.1 ug/L levels. At these ultra-trace levels absolute identification of unknown individual organics becomes increasingly difficult. Many of the ultra-trace organics found in the Coughlan water supply can come from natural sources or as a result of human habitation.

The range of compounds found at an estimated concentration below the 1 ppb level were characterised as:

Aliphatic aldehydes/ketones
Fatty acids and their esters
Aliphatic alcohols
* Aliphatic hydrocarbons
Polyethylene glycol derivatives
* common plasticizers

A number of compounds were tentatively identified at sub-ppb levels and could not be directly associated with natural sources. Due to the low concentrations, good mass spectra could not be obtained and positive identification was not possible. These compounds were:

Benzo-k-fluoranthene (PAH)
Naphthylamine
* Aliphatic amides
* Phenol derivatives
Furanone derivatives
1,1'-(1-methylene-1,2-ethanediyl)bis 4-methoxybenzene
* Nicotine
Naphthalene derivative

These compounds in this combination could all be associated with tobacco and its combustion products (i.e. smoking). Some of the components were confirmed by analysis of a 50 litre XAD resin concentrate of the well water. Compounds that were confirmed are indicated with an asterisk (*) above.

e) Other Class-Specific Scans

Results from other class-specific scans for trace organics are presented in Tables 13 to 16.

2) General Water Quality Assessment

Detailed results from these six off-site private wells for general water quality parameters are listed in Table 9. A discussion of the general characterisation of the wells and any significant findings is presented in Section VI.

3) Bacteriological Assessment

The results of bacteriological analyses on two samples (at approximately 2 and 20 hours of sampling) are presented in Table 10. A discussion of the significance of the bacterial levels may be found in Section VI.

VI DISCUSSION

A. TRACE ORGANIC ANALYSIS

The Chemical Abstracts Service which maintains a registry of organic compounds, synthetic or identified natural products, has now over four million organics registered. Many of these are rare and exotic substances but thousands of synthetic organics are produced in multimillion (often billion) kilogram quantities. Numerous organics are in general industrial and household use. Because of their widespread application, a large number of man-made organic substances enter the ecosystem as contaminants of air, soil and water.

Analysis for millions of organic compounds is clearly an impossible task. In order to develop a workable system, environmental scientists throughout the world felt the need for a selective process by which the formidable number of organic compounds could be reduced to an analytically manageable range. The selection process was guided by considerations regarding human and environmental toxicity, level of production and usage (tonnage), environmental mobility, persistence (stability, biodegradability) and bioaccumulation.

The Priority Pollutant Scan was designed to cover the most environmentally significant contaminants. Detection limits are generally well below levels of environmental or human health significance. This scan also includes a number of widely occurring innocuous substances to assist in data interpretation.

The GC/MS scans show the presence of an extremely wide range of contaminants including those listed as priority pollutants and other compounds present down to sub-ppb levels. This technique can make a positive identification or characterisation of most contaminants even at these ultra-trace concentrations.

It is very difficult to comprehend the sensitivity of modern trace analytical techniques. It is important to note that the numbers in many cases are more representative of detection limits and are not related to the degree of hazard. The ultra-trace concentrations reported must be viewed with this perspective in mind.

Considering a chemical substance (with a specific gravity the same as that of water), a concentration of 1 ppb (1 ug/L) in drinking water means that there is

approximately 1 drop of this substance in 25,000 litres of water. A person drinking this water at the average consumption of 2 L/day would be exposed to two drops of this chemical in 68 years.

During the concentration procedures carried out for the Ames testing on the private wells, extra resin cartridge concentrates were collected from all but the Ballantrae Plaza well. One of these XAD resin cartridges containing the organics trapped from at least 20 litres of water was eluted with methylene chloride to remove the organics, and the eluent was then concentrated. This procedure resulted in an extract concentrated 200,000-fold and this extract was also analysed by GC/MS.

This sampling technique, based on a totally different principle of concentration, was considered to be confirmatory to our usual extraction procedures. The technique however had been optimised for the Ames test for which blanks are considered clean when a negative Ames test is obtained. This does not necessarily mean that the cleaning procedure is adequate for GC/MS. It was in fact discovered after extensive checking, that the mutagen-free blank contained a large number of organic components at the ultra-trace levels determined by the GC/MS analysis used. Further method development has produced procedures which minimise the organics present in the blank and make this approach more suitable for GC/MS.

Using the resin data for each sample to search for specific compounds detected by the usual GC/MS procedure, concentrations determined were comparable to those estimated in the 1 litre extracts.

B. CHARACTERISATION OF LEACHATE WELL 5

Over 96% of the oily material obtained from leachate well 5 could be characterised as petroleum hydrocarbons (gasoline, lubricating and process oils) and high boiling esters such as plasticizers. PCBs were found at levels of 3,000 ppm and various organophosphate esters at lower trace concentrations. Detailed GC/MS analysis of the oil collected from this leachate well confirmed previous findings and did not reveal the presence of any additional hazardous organic components.

The oily waste represents a significant source of potential contamination of the aquifer if its transport were allowed by soil and hydrogeological conditions. Should such event take place in the future, the readily leachable phenolic components (10 mg/L) would be expected to be detectable even after 1000x dilution and give ample warning of impending contamination by more toxic components such as PCBs which are not readily transported by water. The mobility of phenols in water and soil equals that of the chloride ion and in soils of high ion exchange capacity they may even precede inorganic chlorides.

C. TRACE ORGANICS IN THE OBSERVATION WELLS

1) Observation Well 2-75

Only two organic compounds were identified at the low ppb level, isopropyl alcohol (2.8 ug/L) and methyl-ethyl ketone (1.2 ug/L).

At less than 1 ug/L concentrations (0.1 - 0.8 ug/L), chloroform, benzene, toluene, diethyl ether, tetrahydrofuran, methylisobutyl ketone, methylpentanol and naphthalene were identified by the GC/MS scan for volatile organics.

Also at less than 1 ug/L levels, the wood preservative pentachlorophenol was detected by class-specific scans.

2) Observation Well 16-70

This well showed the presence of two organochlorine pesticides and PCBs at the low ng/L levels, pentachlorophenol at high ng/L levels, toluene at 1.4 ug/L and seven volatile organics at less than 1 ug/L levels.

GC/MS analysis showed two well known bulk industrial organics at the low ug/L levels and eight at less than 1 ug/L levels. In addition, the well contained ten coal tar chemicals at less than 1 ug/L levels.

3) Observation Well 1-80

This well is relatively shallow (20 ft.), situated in the central area of the landfill site and was shown to be most contaminated with industrial organics although no PCBs or organochlorine pesticides were detected in this study even at the low ppt levels. Pentachlorophenol was detected in both a filtered and unfiltered sample at low ppb levels.

Over one hundred organics were identified or characterized in OW 1-80. This information will be very useful in future monitoring for indicator trace organics.

In the GC/MS analyses pentachlorophenol is noted as being detected in relatively low concentrations. Table 7 for compound-specific analysis for chlorophenols shows different figures for pentachlorophenol concentrations. These latter figures should be taken as more accurate, as the GC/MS quantitation is based on a non-chlorinated, non-phenolic calibration standard which probably has a significantly different response factor to pentachlorophenol.

D. TRACE ORGANICS IN THE PRIVATE WELLS

Introduction

In all of the private wells analysed, with the exception of the Tranmer well, a variety of volatile aromatic hydrocarbons were identified at less than 1 ug/L (ppb) levels. Some of these aromatic hydrocarbons were also detected at low and sub-ppb levels in the observation wells but m-xylene, which is often found in conjunction with o- and p-xylenes, was not observed in any of the observation wells although it was detected in leachate well 5. These alkyl benzenes, including toluene, are widely found in trace amounts in surface and groundwaters. The major source of these contaminants is gasoline emissions and their widespread occurrence in the natural environment can be attributed to atmospheric transport and precipitation.

In addition, the private wells all contained a similar range of extractable organic compounds. These included steroids, aliphatic hydrocarbons, alcohols, ketones, aldehydes and carboxylic acid esters. Many of these compounds were also identified in the observation wells and would be expected to occur from natural sources or as a result of human habitation. Their presence in the background and control wells of the study helps confirm this conclusion.

1) Ballantrae Plaza Well

This well was selected as the first background well for this study as it could not be affected by the landfill site based on hydrogeological considerations.

The Priority Pollutant Scan for organics did not detect any one of the compounds listed in Table 17, although some were detected using the more sensitive GC/MS scan (purge and trap). The scan for organochlorine pesticides and PCBs with even lower detection limits showed the well water free of any pesticide or PCB contamination.

The number of aromatic hydrocarbons (alkylbenzenes) and aliphatic hydrocarbons indicated that this well sometime in the past may have been

contaminated by petroleum hydrocarbons,. The most likely cause is a gasoline spill which occurred in 1972. Petroleum hydrocarbons moving through soil into the aquifer will mobilize certain organics in the soil. Benzopyrene, some oxidized polycyclic aromatic compounds and naphthylamine were tentatively identified at the less than 1 ug/L levels. These are tobacco combustion products and may be related to the presence of smokers at the site. In general, the Ballantrae Plaza Well contained a larger number of organic compounds than the other background well at M.N.R., and none of the compounds identified here could be associated with the bulk industrial organics seen in the observation wells.

It would appear that the value of the Ballantrae Plaza well as a background well was diminished by a localised source of contamination.

2) Hutchinson Well

The Hutchinson Well was selected as the first drinking water source adjacent to the landfill site. This choice was based on the preliminary finding of a single sample positive mutagenicity result by a university laboratory. The Hutchinson well cannot be classified as purely domestic because of the business activities carried out on this location. The sample analysed contained similar organic compounds to the background wells.

The aliphatic alcohols and ketones are both ubiquitous and have industrial and domestic uses such as grease cutting solvents in detergent formulations and components of quick drying (spray) paints, respectively. At the ultra-trace levels detected, it is not possible to link these compounds with a specific source.

Diethyl ether was found in the Hutchinson well and in the three observation wells. The concentration in the Hutchinson well was less than 0.1 ug/L. It should also be noted that diethyl ether is the major component of starter-fluids (sprays) for diesel and gasoline engines and may have been used at this location in connection with business activities. Solvents such as diethyl ether are also widely used in the laboratory and may have caused background levels in these samples.

A qualitatively important sub-ppb contaminant identified in the Hutchinson well was tri(dichloropropyl)phosphate. This is an industrial flame retardant which has been used in the treatment of household items, especially mattresses. Landfill site observation and leachate wells have been repeatedly analysed for the tri(dichloropropyl)phosphate but this particular compound was absent in every case. Since this compound was not detected in on-site wells, the tri(dichloropropyl) phosphate probably has a local origin. A repeat sampling and analysis on May 5, 1982, of the Hutchinson well did not detect the presence of any phosphate esters.

The range of compounds identified at less than 1 ug/L levels in the extractable portion of the Hutchinson water did not correspond to bulk industrial organics. These compounds likely could have been derived from natural sources or could have resulted from human habitation.

3) M.N.R. Well

The M.N.R. well was selected as the second background well for this survey as it was more than 2 km from the site and therefore could not be impacted by the site. The volatile organics detected in this well were similar in type, smaller in number and at lower concentrations than in the Ballantrae Plaza well. All compounds were at the detection limit and at these trace levels, it is not possible to link them with a specific source. The extractable organics showed a slightly different profile from the Ballantrae Plaza well, the main feature being the absence of polycyclic aromatic compounds. The background levels of organics in this well did not appear to differ significantly from the private wells adjacent to the landfill site.

4) Fockler Well

The Fockler well was selected as a second drinking water well adjacent to the landfill site.

Both the volatile and extractable organics in this well were present at extremely low levels which in the case of the extractables would not normally be detected with our standard analytical procedure. Many of the same types of compounds seen in the background and control wells were also found in this location.

The aliphatic alcohols and ketones are naturally occurring and have industrial and domestic uses such as grease cutting solvents in detergent formulations and components of quick drying (spray) paints, respectively. At the ultra-trace levels detected, it is not possible to link these compounds with a specific source.

No industrial organics, other than those used commonly in household products such as in plastics and food products were found in this well. In addition, no other compounds detected in the observation wells and indicated to be bulk industrial organics of wide application, were seen in the Fockler well.

5) Tranmer Well

The Tranmer well was selected as a control well, which had exhibited localised impacts which could not be related to the landfill site due to hydrogeological considerations.

This well contained no volatile (purgeable) organic compounds, which is an unusual occurrence. The extractable organics were in general similar to those seen in the other background wells, and many of the compounds could be derived from natural sources or be associated with human habitation. The presence of nicotine and other combustion products are thought to be associated with tobacco smoking.

6) Coughlan Well

This well was the second control well in this study as it exhibited localised impacts unrelated to the landfill site. The sample from the Coughlan "well" was not obtained directly from the well. It could only be taken after the well's contents had been pumped to a cistern from which a gravity line flowed to the Coughlan residence. The sample was actually obtained from the gravity line.

The purgeable organics were similar to those found in the background wells. Most of the extractable organics were also similar in type and levels to those seen in other off-site wells. In addition, tobacco combustion products were detected including a compound (furanone derivative) which is used as a flavouring agent for tobacco. As with the Tranmer well, one or more of the residents at this site was a smoker.

E. GENERAL WATER QUALITY ASSESSMENT OF THE PRIVATE WELLS

The following is a general characterisation and evaluation of the standard water quality parameters. Unless otherwise indicated the water quality data shown for the six private wells meet Ontario drinking water quality criteria.

The waters would be considered very hard but this is common in areas with thick topsoil and limestone formations. Calcium and magnesium are the cations generally responsible for the hardness of water and thus their levels vary widely with the hardness. Alkalinity is often referred to as temporary hardness; that is, the scale which forms when water is boiled. Most Southern Ontario water is scale producing as opposed to the corrosive nature of some soft acid waters in the north.

The levels of iron in the Hutchinson, M.N.R., Fockler and Coughlan wells were below the drinking water quality objective of 0.3 mg/L. The levels of iron in the Ballantrae and Tranmer wells are above this objective and could certainly be responsible for some taste and odour and staining problems, but do not represent a health hazard. There are many wells in southern Ontario which exhibit equally high or higher levels of iron.

The limit set for chloride in drinking water is 250 mg/L for taste reasons. These wells are well below this limit and, in fact, most are lower than the water from Lake Ontario (30-35 mg/L). The levels measured are however considered to be above typical background levels (1 to 5 mg/L) for the area. The elevated levels of both sodium and chloride in the Coughlan well could indicate surface water contamination. The sodium concentrations in the other five wells fall on the low side of the normal range. The recommended limit for those on a "totally" salt free diet has been set at 2 litres of water per day containing no more than 20 mg/L of sodium.

The maximum acceptable level of phenols is 2 ug/L and is based on aesthetic considerations. While not normally present in well waters, they may originate from contaminated surface water or may result from the breakdown of naturally occurring humic materials.

Nitrite and nitrate concentrations are of concern if the water is to be consumed by an infant (under 7 months of age). High levels may lead to methemoglobinemia and the level of nitrate (28 mg/L as N) in the Coughlan well is cause for concern. No cases of this disease have been reported in areas where the total nitrite and nitrate concentration is less than 10 mg/L as N. Extremely high levels are sometimes associated with farm areas in which large amounts of chemical fertilizers are employed. In conjunction with the elevated (20.2 mg/L as K) level of potassium, contamination of the Coughlan well by chemical fertilizers may be indicated.

With the exception of the above parameters, the analysis of these six wells indicates that they are within the normal ranges for potable groundwaters in southern Ontario. Within the scope of this study, it has not been possible to fully relate well water quality to natural background conditions for the area. Also, this study, based on the analysis of single samples, cannot specifically access changes that may have occurred in the quality of the off-site private wells.

F. BACTERIOLOGICAL ASSESSMENT OF THE PRIVATE WELLS

The following is a general discussion of the bacterial levels determined in the private off-site wells.

The water from the Ballantrae Well contained no indicator bacteria representative of disease-causing bacteria. The heterotrophic plate count at 35°C was too low to be of any significance. No iron bacteria were present, but the low levels of sulphate-reducing bacteria may require treatment of the well by superchlorination at some future date to prevent odour and corrosion activity from occurring. No odour or sediment was present in the sample, which was slightly turbid. The higher level of sulphate-reducers after 20 hours indicates some proliferation of the bacteria within the aquifer.

The samples from the Hutchinson Well contained no indicator bacteria representative of disease-causing bacteria. The heterotrophic plate count at 35°C was too low to be of any significance. Some iron bacterial activity was present with the identification of some sheath material from the organism Leptothrix. No sulphate-reducing bacteria were present after 26 days of incubation.

The water from the M.N.R. well contained no indicator bacteria representative of disease-causing bacteria. The presence-absence (P-A) test indicated the presence of a coagulase-negative Staphylococcus sp. The total coliform background count and the heterotrophic bacterial counts were too low to be of any significance. No iron bacteria or sulphate-reducing bacteria were detected.

The water from the Fockler well showed the presence of coliform bacteria in the initial sample by the P-A test but not by membrane filter test. No indicator organisms were present in the final sample. This low level of coliform bacteria would not be representative of hazardous conditions but could indicate contamination from local human habitation. Traces of the iron bacterium Gallionella also were present in the initial sample along with detectable levels of sulphate-reducing bacteria. Only sulphate-reducing organisms were still present at the same level in the final sample. Treatment of the well with chlorinated bleach at 100-200 mg/L should effectively eliminate these organisms which will otherwise become a nuisance with objectionable tastes and odours.

The water samples from the Tranmer well contained no indicator bacteria representative of disease-causing bacteria. The heterotrophic bacterial counts were too low to be of any significance. No iron or sulphate-reducing bacteria were detected.

The Coughlan well samples contained low levels of both total coliforms and fecal coliforms in the initial sample and in the final sample. Heterotrophic bacteria were present at very low levels. No iron or sulphate-reducing bacteria were present. The low levels of total and fecal coliforms would not usually represent hazardous water quality, but the well water and distribution system should be treated with chlorinated bleach to effectively eliminate their presence. Further samples should be taken for several days to a week to determine the effectiveness of the disinfection procedure.

G. SUMMARY

A summary of all the organics identified in the well samples analysed in this study is given in Table 23. In addition, the concentrations of the compounds, where calculated or estimated, are also included. Some of the organics were detected in more than one location while others were specific to a particular well.

The observation wells contained some compounds which also were identified in leachate well 5. The calculated concentrations of the compounds which were common were, in all cases but one, at least 1,000 times less in the observation wells. All three observation wells contained some light aromatic hydrocarbons (benzene, toluene, xylenes) at low or sub-ppb levels. These aromatics are commonly found in environmental samples including both surface and ground water. Their widespread use in petroleum products and their presence in gasoline emissions indicates that their occurrence may be explained by atmospheric transport and precipitation.

The observation wells also contained chloroform close to the detection limit of the method and at least 100 times lower a concentration than in leachate well 5. Trichloroethylene which is a commonly used degreasing solvent was found at less than 1 ug/L levels in OW 1-80 as well as at much higher levels in leachate well 5. PCBs were observed in OW 16-70 at low ng/L levels, close to the detection limit of the methodology. Aroclor 1248 was detected in leachate well 5 at levels 10^8 times higher than found in the observation well. The few other compounds found in leachate well 5 and also in one or more of the observation wells are present at less than 1 ug/L levels in the observation wells and could be associated with natural sources, plastics or spent crank-case oil.

A few compounds were identified in the three observation wells which were not also identified in the leachate well 5 sample. These included pentachlorophenol, diethyl ether, carboxylic acids and aliphatic alcohols. A number of other compounds were identified in more than one of the observation wells. These included isopropanol, methyl-ethyl ketone, octanoic acid, molecular sulfur, carboxylic acids and derivatives, aliphatic ketones and aldehydes. A few of these compounds are likely of natural origin (e.g. molecular sulfur) but many are also used as bulk industrial chemicals. The majority of organics identified on-site were found in a single location only and the overlap was minimal.

All the private well samples except that from the Tranmer well contained a number of volatile aromatic hydrocarbons which were also observed, at higher concentrations in leachate well 5 and in one or more observation wells. These alkyl benzenes are ubiquitous at trace levels in surface and groundwaters throughout the province. In addition, levels of chloroform close to the detection limit of the method, were measured in three of the private wells including the two wells adjacent to the landfill and in one background well. Chloroform was also detected at levels close to the detection limit in all observation wells and at higher levels in leachate well 5. As well as being an industrially used chemical, chloroform is commonly found in municipal water supplies which have been chlorinated. It can also be produced by the use of bleach in private wells and could be detected at such low levels for some time after the disinfection process.

A number of aliphatic hydrocarbons were observed in all wells except Ballantrae Plaza and leachate well 5 (in the latter case probably because the appropriate fractions were not suitable for trace analysis); all except the Hutchinson well contained esters of long chain acids and all except leachate well 5 contained aliphatic alcohols. Each of these groups of compounds could be derived from natural sources or associated with human habitation.

The Fockler and Coughlan wells contained ultra-trace levels of styrene which was also identified in leachate well 5. The Fockler well also contained an ultra-trace level of diethyl phthalate in common with leachate well 5. This latter compound is very widely used in plastics and is often found to be due to sample contamination rather than being attributed to a particular site. Three of the background/control wells contained polyethylene glycol derivatives which were also observed in two of the on-site wells. These compounds as well as being common industrial chemicals are also found in products used in most households.

A number of volatile organics were observed in the private wells in addition to at least one of the observation wells. The M.N.R. and Ballantrae Plaza samples contained ultra-trace levels of a commonly used ketone, while the Fockler well contained a similar level of another ketone and the Hutchinson well contained a level of diethyl ether very close to the method's detection limit. These compounds have domestic as well as industrial uses. They can be used as grease-cutting solvents in detergent formulations, as components of quick drying (spray) paints and starter fluids for diesel and gasoline engines.

Trace levels of carboxylic acids were observed in three background/control wells and also in all three observation wells. While some of these are industrial chemicals, they could also derive from natural sources. Aliphatic aldehydes and ketones, which can also be associated with human habitation, were found in all private wells, except Fockler and Tranmer, and in two of the observation wells. All the private wells except Ballantrae Plaza and Coughlan contained a steroid which was also seen in OW 1-80. Steroids are also derived from natural sources. The widespread presence of the above groups of compounds would indicate that their presence could not be linked with a point source.

The M.N.R. well contained methyl styrene which was also observed in OW 16-70, while the Coughlan well contained benzo-k-fluoranthene in common with OW 16-70. The methyl styrene is a component of plastic materials while the benzo-k-fluoranthene in the Coughlan well was linked, by the presence of associated compounds, with tobacco and its combustion products.

The other compounds identified at ultra-trace levels in the private wells were not observed in the on-site wells. The range of compounds that were found in the private wells adjacent to the site and also in the on-site wells are organics which are so commonly found in other locations (as demonstrated here with the presence of many of them being in the background and control wells) that it is impossible to pinpoint their source or to link their presence in the private wells with their presence in the on-site wells.

VII CONCLUSIONS

Over 96% of the organics in the sample from the oily layer of leachate well 5 sample consist of waste oils and petroleum hydrocarbons with a relatively high leachable phenol content. Thus, if organic contamination of neighbouring wells were to occur from this source, this would probably manifest itself as a phenol nuisance problem well before contamination reached levels that could be classified as a significant health hazard.

The fingerprinting of the oily layer of leachate well 5 indicated a profile of aromatic hydrocarbons, including some polycyclic aromatics, esters of various acids including phosphates and phthalates, PCBs, some chlorinated aliphatics and a few miscellaneous compounds. Total PCB contamination was less than 1% of the oil. Many of these compounds would not be suitable for monitoring future movement of organics because of their widespread occurrence at trace levels in surface and groundwaters.

The most significant substances detected in this study were PCBs which are not readily transported through soil by water. No PCBs were detected in OW 2-75, OW 1-80 or in any of the private off-site wells including Hutchinson and Fockler. Levels of PCBs were just above the detection limit in OW 16-70.

Analytical data have shown that the observation wells generally contain low levels of trace metals. Furthermore, the pH of the groundwater on the landfill site is rather on the alkaline side, not conducive for the mobilization and transport of heavy metals.

The observation wells contained a wide variety of organic compounds identified by the GC/MS analysis. Many of these, especially in OW1-80 were identified as bulk industrial organics of wide application, but only in OW1-80 were a significant number of these compounds at levels greater than 1 ug/L.

The increase in sensitivity attained by adjusting the MOE standard methods for the analysis of organic components in the private wells has been able to pinpoint ultra-trace concentrations of a wide range of organics. Many of these organics can be derived from natural sources, human habitation or are generally

distributed as air pollutants. In particular, the lower aromatic hydrocarbons such as benzene, toluene and xylene are widely distributed in the environment from a variety of sources. Other compounds found, such as the aliphatic alcohols and ketones, are used in detergent formulations and components of quick-drying spray paints, respectively. In general the background and control wells contained similar types and variety of organics with minor variations depending on the location. Many of these ultra-trace components could not be positively identified but in general the chemical class of the compound could be determined.

No industrial organics, other than those commonly used in household products such as in plastics and food products were found in the private wells. None of the bulk industrial organics detected in the three observation wells were seen in any of the off-site private wells.

The objectives described in the Introduction to this report have been achieved as follows:

1) The contents of the oily layer from leachate well 5 have been analysed and the identity and levels of many on-site chemicals in proximity to former lagoon 5 have been determined.

2) The organics present in the three observation wells have been identified.

3) Two selected off-site private wells adjacent to the landfill site have been analysed and the chemicals present have been compared to those appearing on the site.

4) Four private wells not affected by the landfill site have been analysed in order to determine background levels of chemicals.

5) A trace organic profile of each of the four on-site wells has been established.

Specific standards do not exist for many of the trace organics detected in the off-site private wells. However based on the standards that are established under federal and provincial drinking water quality criteria the results of this study

indicate that the Hutchinson and Fockler wells, the two background wells (Ballantrae Plaza and M.N.R.) and a control well (Tranmer) are potable. The second control well (Coughlan) contained poor quality water due to the presence of elevated levels of nitrate and bacterial indicators. The presence of those organics for which drinking water standards are not currently established is not considered to be a problem at the ultra-trace levels measured. In this study it has not been possible to link the ultra-trace organics in the Hutchinson and Fockler wells with a specific source. Also, this study, based on the analysis of single samples, cannot specifically access changes that may have occurred in the quality of the off-site private wells.

The organic contents of the oily layer of leachate well 5 represent a potential hazard for future off-site contamination; however based on the analytical data contained in this report, there is no conclusive evidence that such contamination is occurring at the present time.

VIII APPENDICES

A. ANALYTICAL DATA TABLES

1. Leachate Well 5

Table 1

Headspace Analysis

Volatile Organics (mg/L)

Sample	Date Received	Pentane	2,2-Dimethylbutane	2,3-Dimethylbutane	3-Methylpentane	Hexane	2,4-Dimethylpentane	Cyclohexane	2,3-Dimethylpentane	3-Methylhexane	2,2,4-Trimethylpentane	Heptane	Benzene	Methylcyclohexane
Leachate Well #5 (oil layer on liquid phase)	23/02/82	2.96	1.10	nd	6.03	37.6	9.34	nd	nd	23.0	nd	35.1	21.6	5.10

Sample	2,3,4-Trimethylpentane	3-Methylheptane	Octane	Toluene	Nonane	Ethylbenzene	p-Xylene	m-Xylene	o-Xylene	Cumene	Styrene	Decane	n-Propylbenzene
Leachate Well #5 (oil layer on liquid phase)	nd	13.1	8.90	328	1.40	236	174	383	190	7.4	5.9	nd	nd

Sample	o-Chlorotoluene	Mesitylene	p-Cymene	Undecane	m-Dichlorobenzene	Methylene Chloride	Carbon Tetrachloride	Chloroform	Trichloroethylene	Bromodichloromethane	Tetrachloroethylene	Chlorodibromomethane
Leachate Well #5 (oil layer on liquid phase)	nd	nd	nd	nd	nd	0.53	0.03	0.01	0.30	nd	0.09	nd

Detection Limits: all 0.05 µg/L

nd = non-detectable tr = trace (less than 0.1 µg/L) * = approximate results, response of standard not determined

Note: analysis by headspace technique, 85°C, 1 h

2. Observation Wells

Table 2

Sample	Date Received	Calcium (UR) mg/L	Magnesium (UR) mg/L	Hardness as $CaCO_3$ mg/L	Alkalinity as $CaCO_3$ mg/L	Iron as Fe (UT) mg/L	Chloride as Cl (UR) mg/L	pH µmho/cm	Conductivity (25°C) mg/L	Sodium as Na (UR) mg/L	Nitrogen as N: Free Ammonia (FR) mg/L	Nitrogen as N: Total Kjeldahl (UR) mg/L	Nitrogen as N: Nitrite (FR) mg/L	Nitrogen as N: Nitrate (FR) mg/L	Dissolved Organic Carbon (DOC) mg/L	Dissolved Inorganic Carbon (DIC) mg/L	Phenol µg/L	Chemical Oxygen Demand (COD) as O mg/L	Manganese as Mn (UR) mg/L	Sulphate as SO_4 (UR) mg/L	Potassium as K (UR) mg/L	Fluoride as F (UR) mg/L
OW 16-70	7/01/82	136	15	401	336	0.35	58	7.74	930	49.5	nd	0.4	0.01	0.4			2*	35		91	2.3	
OW 2-75		118	18	368	360	2.10	49	7.62	790	27.0	nd	0.4	0.01	nd			1*	40		3	1.4	
OW 1-80		206	30	652	628	12.00	104	7.28	1420	79.0	nd	1.0	0.01	nd	280.0	158.0	6*	140		15	2.6	
Detection Limits		0.8	0.2	0.8	1.5	0.01	1.6		2.4	0.5	0.1	0.1	0.01	0.1	0.4	0.6	1.0	4		2.2	0.5	0.1

nd = non-detectable U = unfiltered F = filtered R = reactive T = total (unless otherwise indicated) * sample not properly preserved

Table 3

Sample	Date Received	Metals																					
		Arsenic (As) mg/L	Antimony (Sb) mg/L	Molybdenum (Mo) mg/L	Zinc (Zn) mg/L	Lead (Pb) mg/L	Cadmium (Cd) mg/L	Cobalt (Co) mg/L	Chromium (Cr) mg/L	Vanadium (V) mg/L	Aluminum (Al) mg/L	Beryllium (Be) mg/L	Copper (Cu) mg/L	Titanium (Ti) mg/L	Strontium (Sr) mg/L	Bismuth (Bi) mg/L	Barium (Ba) mg/L	Nickel (Ni) mg/L	Selenium (Se) mg/L	Cyanide (CN) µg/L	Thallium (Tl) mg/L	Silver (Ag) mg/L	Mercury (Hg) µg/L	Manganese (Mn) mg/L
OW 16-70	19/11/81	.001		.008	.66	.24	.006	.037	.025	nd	.61	nd	2.6	.022			.17	.043						.26
OW 16-70 filt.		nd		.008	.16	.010	.003	.006	.004	nd	.088	nd	.031	nd			.042	.006						.065
OW 2-75	19/11/81	nd		.002	.34	.12		.026	.024	nd	.28	nd	1.0	.004			.18	.046						.15
OW 2-75 filt.		nd		.001	.12	.004	.002	.004	.004	.002	.10	nd	.045	nd			.090	.006						.059
OW 1-80*	23/11/81	.002		.014	24	.050	.0004	.054	.070	.044	21	.001	.24				.27	.077						1.4
OW 1-80 filt.		.001		.005	.33	nd		.020	.010	.020	.20	nd	.018	nd			.15	.032						1.0
Detection Limits		0.001		.001	.001	.003	.0002	.001	.001	.001	.001	.001	.001	.001			.001	.001						.001

nd = non-detectable * Results are approximate, heterogeneous sample

Detection limits indicated were the highest ones observed and were selected in order to provide data with the lowest possible determinate error. In some cases actual detection limits were lower than these values. All parameters are unfiltered, total unless otherwise indicated. Not all data reported on LIS; part of multi-element scan.

Table 4

Sample	Date Received	Volatile Organohalides						Organophosphate Pesticides												
		Chloroform $CHCl_3$ µg/L	Carbon Tetrachloride CCl_4 µg/L	Trichloroethylene C_2HCl_3 µg/L	Dichlorobromomethane $CHCl_2Br$ µg/L	Tetrachloroethylene C_2Cl_4 µg/L	Dibromochloromethane $CHClBr_2$ µg/L	Dichlorvos µg/L	Thimet µg/L	Mevinphos µg/L	Diazinon µg/L	Ronnel µg/L	Parathion µg/L	Methyl Parathion µg/L	Malathion µg/L	Ethion µg/L	Methyl Trithion µg/L	Dursban µg/L	Reldan µg/L	Guthion µg/L
OW 16-70	7/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 2-75		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 1-80		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		1	0.1	2	0.5	0.1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.10	0.01	0.01	1.0

nd = non-detectable

Table 5

Sample	Date Received	Organochlorine Pesticides																					
		Hexachlorobenzene ng/L	Alpha BHC ng/L	Beta BHC ng/L	Gamma BHC ng/L	Heptachlor ng/L	Heptachlor Epoxide ng/L	Aldrin ng/L	Dieldrin ng/L	Endrin ng/L	Alpha Chlordane ng/L	Gamma Chlordane ng/L	pp'DDE ng/L	pp'DDD ng/L	op'DDT ng/L	pp'DDT ng/L	Methoxy Chlor (DMDT) ng/L	Mirex ng/L	Thiodan I ng/L	Thiodan II ng/L	Thiodan Sulphate ng/L	Oxychlordane ng/L	PCB's ng/L
OW 16-70	7/01/82	nd	nd	4	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	25
OW 16-70 filt.		nd	nd	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 2-75		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 2-75 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 1-80		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 1-80 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		1	1	1	1	1	1	1	2	4	2	2	1	5	5	5	4	5	2	4	4	2	20

nd = non-detectable

Table 6

Sample	Date Received	Chlorophenoxy Acid Herbicides							Triazine Herbicides							
		Dicamba µg/L	2,4-DP µg/L	2,4-D µg/L	Silvex µg/L	2,4,5-T µg/L	2,4-DB µg/L	Picloram µg/L	Prometone µg/L	Propazine µg/L	Atrazine µg/L	Prometryne µg/L	Simazine µg/L	Ametryne µg/L	Sencor µg/L	Bladex µg/L
OW 16-70	7/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 16-70 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 2-75		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 2-75 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 1-80		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
OW 1-80 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		0.1	0.1	0.1	0.05	0.05	0.2	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1

nd = non-detectable

Table 7

Sample	Date Received	Chlorinated Benzenes (and Related Compounds)														Chlorophenols						TCDD's
		Hexachloroethane µg/L	1,3,5-Trichlorobenzene µg/L	1,2,4-Trichlorobenzene µg/L	1,2,3-Trichlorobenzene µg/L	Hexachlorobutadiene µg/L	2,4,5-Trichlorotoluene µg/L	2,3,6-Trichlorotuluene µg/L	1,2,4,5-Tetrachlorobenzene µg/L	1,2,3,5-Tetrachlorobenzene µg/L	2,6-alpha-Trichlorotoluene µg/L	1,2,3,4-Tetrachlorobenzene µg/L	Pentachlorobenzene µg/L	Hexachlorobenzene µg/L	Octachlorostyrene µg/L	2,4,6-Trichlorophenol µg/L	2,4,5-Trichlorophenol µg/L	2,3,4-Trichlorophenol µg/L	2,3,5,6-Tetrachlorophenol µg/L	2,3,4,5-Tetrachlorophenol µg/L	Pentachlorophenol µg/L	Tetrachlorodibenzo -p-dioxins ng/L
OW 16-70	7/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.2	
OW 16-70 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.3	
OW 2-75		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	.06	
OW 2-75 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.1	
OW 1-80		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	4.4	
OW 1-80 filt.		nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	3.4	
Detection Limits		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.1	0.05	0.05	0.05	0.2

nd = non-detectable

Table 8

Sample	Date Received	Trialkyl-/arylphosphates											Miscellaneous		
		Tri(butyl)phosphate µg/L	Tri(2-chloroethyl) phosphate µg/L	Tri(dichloropropyl) phosphate µg/L	Tri(phenyl)phosphate µg/L	Tri(butoxyethyl) phosphate µg/L	o-Isopropylphenyl-diphenylphosphate µg/L	Tri(o-tolyl)phosphate µg/L	Tri(m-tolyl)phosphate µg/L	Tri(p-tolyl)phosphate µg/L	p-tertbutylphenyl-diphenylphosphate µg/L	Tri(2,4-xylyl)phosphate µg/L	Methylene blue active substances (LAS) mg/L	Total phosphorus mg/L	Dissolved reactive phosphorus mg/L
OW 16-70	8/01/82	nd	nd	nd	*	nd	*	nd	nd	nd	nd	nd	nd	0.18	nd
OW 2-75		nd	nd	nd	*	nd	*	nd	nd	nd	nd	nd	nd	0.32	0.16
OW 1-80		nd	nd	nd	*	nd	*	*	*	nd	*	nd	2.75	9.6	0.02
Detection Limits		* Positive results were due to contamination from the samplers' gloves - see Appendix C for discussion.											0.1	0.02	0.02

nd = non-detectable

3. Private Wells

Table 9

Sample	Date Received	General Water Quality Parameters																				
		Calcium (UR) mg/L	Magnesium (UR) mg/L	Hardness as $CaCO_3$ mg/L	Alkalinity as $CaCO_3$ mg/L	Iron as Fe (UT) mg/L	Chloride as Cl (UR) mg/L	pH µmho/cm	Conductivity (25°C) mg/L	Sodium as Na (UR) mg/L	Nitrogen as N: Free Ammonia (FR) mg/L	Nitrogen as N: Total Kjeldahl (UR) mg/L	Nitrogen as N: Nitrite (FR) mg/L	Nitrogen as N: Nitrate (FR) mg/L	Dissolved Organic Carbon (DOC) mg/L	Dissolved Inorganic Carbon (DIC) mg/L	Phenol µg/L	Chemical Oxygen Demand (COD) as O mg/L	Manganese as Mn(UR) mg/L	Sulphate as SO_4 (UR) mg/L	Potassium as K (UR) mg/L	Fluoride as F (UR) mg/L
Ballantrae Plaza	26/01/82	74 (67UT)	12 (19UT)	237	167	.77 .85	14	7.99	470	4.5	nd	0.2	0.01	nd	0.8	39	2	10		61	1.4	
Hutchinson	9/02/82	125 (126UT)	20 (18UT)	393	297	.051 .01	28	7.39	720	5.0	nd	0.3	nd	0.1	2.8	80	nd	nd		63	1.3	
M.N.R.	23/02/82	81 (71UT)	17 (14UT)	271	214	.02 .02	27	7.49	540	8.0	nd	nd	0.02	0.7	0.5		nd	6		32	1.8	0.06
Fockler	9/03/82	107 (100UT)	10 (13UT)	310	282	nd .009	9	7.51	580	8.5	nd	nd	0.01	0.2	1.1			nd		28	0.8	0.05
Tranmer	23/03/82	98 (84UT)	14 (18UT)	301	201	.61	52	7.84	600	7.5	nd	0.4	0.01	1.9	0.6		nd	nd		30	1.0	0.06
Coughlan	30/03/82	138 (120UT)	23 (26UT)	440	296	.02	83	7.14	1085	43.0	nd	0.4	0.01	28.0	1.9		nd	6		52	20.2	0.04
Detection Limits		0.8	0.2	0.8	1.5	0.01	1.6		2.4	0.5	0.1	0.1	0.01	0.1	0.4	0.6	1.0	6	0.002	2.2	0.5	0.1

nd = non-detectable U = unfiltered F = filtered R = reactive T = total (unless otherwise indicated)

Table 10
Microbiology

Sample	Date Received	Membrane Filtration: Total Coliforms (TC) /100 mL	TC Background (BKG) /100 mL	Fecal Coliforms (FC) /100 mL	Fecal Streptococci (FS) /100 mL	Heterotrophic Bacteria (35°C) (HB) /100 mL	P-A: Presence-Absence	Nuisance Organisms: Iron Bacteria: Identification	Crenothrix	Sphaerotilus	Gallionella	Leptothrix	Sulphate Reducers
Ballantrae													
Plaza 4 hours	25/01/82	0	0			1	absent		-	-	-	-	+(10-99/100mL)
20 hours	26/01/82	0	0			3	absent		-	-	-	-	+(100-999/100mL)
Hutchinson													
0 hours	9/02/82	0	0			8	absent		-	-	-	+	-
20 hours	9/02/82	0	0			6	absent		-	-	-	+	-
M.N.R.													
2 hours	23/02/82	0	0			3	absent		-	-	-	-	-
20 hours	23/02/82	0	4			1	present FS absent CP absent SA absent PSA absent TC absent AE absent FC absent						

nd = non-detectable

Table 10 cont.

Microbiology

Sample	Date Received	Membrane Filtration: Total Coliforms (TC) /100 mL	TC Background (BKG) /100 mL	Fecal Coliforms (FC) /100 mL	Fecal Streptococci (FS) /100 mL	Heterotrophic Bacteria (35°C) (HB) /100 mL	P-A: Presence-Absence	Nuisance Organisms: Identification	Iron Bacteria: Crenothrix	Sphaerotilus	Gallionella	Leptothrix	Sulphate Reducers	
Fockler														
2 hours	9/03/82	0	0			2	present FS absent CP absent SA absent PSA absent TC present AE absent FC absent		-	-	+	-	+	(10-99/100 mL)
20 hours	9/03/82	0	0			0	absent		-	-	-	-	+	(10-99/100 mL)
Tranmer 0 hours	23/03/82	0	0			2	absent		-	-	-	-	-	
20 hours	23/03/82	0	0			12	absent		-	-	-	-	-	

nd = non-detectable

Table 10 cont.

Microbiology

Sample	Date Received	Membrane Filtration: Total Coliforms (TC) /100 mL	TC Background (BKG) /100 mL	Fecal Coliforms (FC) /100 mL	Fecal Streptococci (FS) /100 mL	Heterotrophic Bacteria (35°C) (HB) /100 mL	P-A: Presence-Absence	Nuisance Organisms: Iron Bacteria: Identification	Crenothrix	Sphaerotilus	Gallionella	Leptothrix	Sulphate Reducers
Coughlan 2 hours	30/03/82	2	0			7	present FS absent CP absent SA absent PSA absent TC present AE absent FC present		-	-	-	-	-
20 hours	30/03/82	0	0			3	present FS absent CP absent SA absent PSA absent TC present AE absent FC present		-	-	-	-	-

nd = non-detectable

FS = fecal streptococci
CP = Clostridium perfringens
SA = Staphylococcus aureus
PSA Pseudomonas aeruginosa
AE = Aeromonas sp.

Table 11

Sample	Date Received	Metals																						
		Arsenic (As) mg/L	Antimony (Sb) mg/L	Molybdenum (Mo) mg/L	Zinc (Zn) mg/L	Lead (Pb) mg/L	Cadmium (Cd) mg/L	Cobalt (Co) mg/L	Chromium (Cr) mg/L	Vanadium (V) mg/L	Aluminum (Al) mg/L	Beryllium (Be) mg/L	Copper (Cu) mg/L	Titanium (Ti) mg/L	Strontium (Sr) mg/L	Bismuth (Bi) mg/L	Barium (Ba) mg/L	Nickel (Ni) mg/L	Selenium (Se) mg/L	Cyanide (CN) * mg/L	Thallium (Tl) mg/L	Silver (Ag) mg/L	Mercury (Hg) µg/L	Manganese (Mn) mg/L
Ballantrae Plaza	26/01/82	nd		.006	.020	.005	nd	.004	.002	.002	.042	nd	.033	nd	.089		.100	.002		nd	nd		nd	.026
Hutchinson	9/02/82	nd		.006	.081	.007	.0003	.004	.004	.003	.080	nd	.066	nd	.081		.043	.003		nd	nd		.01	.019
M.N.R.	23/02/82	.004		.004	nd	.004	nd	.002	.004	.001	.051	nd	.009	nd	.060		.063	.003	.001	nd	nd	nd	nd	.004
Fockler	9/03/82	nd		.003	.200	nd	.0001	nd	.004	.003	.094	nd	.056	nd	.052		.034	nd		nd	nd		nd	.004
Tranmer	23/03/82	nd		.002	.180	.005	nd	.001	.004	.002	.094	nd	.014	nd	.077		.040	nd	nd	nd	.002	nd	nd	.006
Coughlan	30/03/82	nd		.003	.012	.004	nd	nd	.006	.003	.140	nd	.032	nd	.160		.056	nd	nd	nd	nd	.0024	nd	.002
																				nd**				
Detection Limits		0.001		.001	.001	.003	.0001	.001	.001	.001	.001	.001	.001	.001	.001		.001	.001		.005	.002	.0005	***	.001

nd = non-detectable * unfiltered, reactive ** available, unfiltered, reactive *** detection limits ranged from .01 to .06 µg/L

Detection limits indicated were the highest ones observed and were selected in order to provide data with the lowest possible determinate error. In some cases actual detection limits were lower than these values. All parameters are unfiltered, total unless otherwise indicated.

Table 12

Sample	Date Received	Organochlorine Pesticides																					
		Hexachlorobenzene ng/L	Alpha BHC ng/L	Beta BHC ng/L	Gamma BHC ng/L	Heptachlor ng/L	Heptachlor Epoxide ng/L	Aldrin ng/L	Dieldrin ng/L	Endrin ng/L	Alpha Chlordane ng/L	Gamma Chlordane ng/L	pp'DDE ng/L	pp'DDD ng/L	op'DDT ng/L	pp'DDT ng/L	Methoxy Chlor (DMDT) ng/L	Mirex ng/L	Thiodan I ng/L	Thiodan II ng/L	Thiodan Sulphate ng/L	Oxychlordane ng/L	PCB's ng/L
Ballantrae Plaza	26/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hutchinson	9/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
M.N.R.	23/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fockler	9/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tranmer	23/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Coughlan	30/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		1	1	1	1	1	1	1	2	4	2	2	1	5	5	5	4	5	2	4	4	2	20

nd = non-detectable

Table 13

Sample	Date Received	Volatile Organohalides						Organophosphate Pesticides												
		Chloroform $CHCl_3$ µg/L	Carbon Tetrachloride CCl_4 µg/L	Trichloroethylene C_2HCl_3 µg/L	Dichlorobromomethane $CHCl_2Br$ µg/L	Tetrachloroethylene C_2Cl_4 µg/L	Dibromochloromethane $CHClBr_2$ µg/L	Dichlorvos µg/L	Thimet µg/L	Mevinphos µg/L	Diazinon µg/L	Ronnel µg/L	Parathion µg/L	Methyl Parathion µg/L	Malathion µg/L	Ethion µg/L	Methyl Trithion µg/L	Dursban µg/L	Reldan µg/L	Guthion µg/L
Ballantrae Plaza	26/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hutchinson	9/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
M.N.R.	23/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fockler	9/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tranmer	23/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Coughlan	30/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		1	0.1	2	0.5	0.1	1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.10	0.01	0.01	1.0

nd = non-detectable

Table 14

Sample	Date Received	Chlorophenoxy Acid Herbicides							Triazine Herbicides							
		Dicamba µg/L	2,4-DP µg/L	2,4-D µg/L	Silvex µg/L	2,4,5-T µg/L	2,4-DB µg/L	Picloram µg/L	Prometone µg/L	Propazine µg/L	Atrazine µg/L	Prometryne µg/L	Simazine µg/L	Ametryne µg/L	Sencor µg/L	Bladex µg/L
Ballantrae Plaza	26/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hutchinson	9/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
M.N.R.	23/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fockler	9/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tranmer	23/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Coughlan	30/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Detection Limits		0.1	0.1	0.1	0.05	0.05	0.2	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1

nd = non-detectable

Table 15

Sample	Date Received	Chlorinated Benzenes (and Related Compounds)														Chlorophenols						TCDD's
		Hexachloroethane µg/L	1,2,5-Trichlorobenzene µg/L	1,2,4-Trichlorobenzene µg/L	1,2,3-Trichlorobenzene µg/L	Hexachlorobutadiene µg/L	2,4,5-Trichlorotoluene µg/L	2,3,6-Trichlorotuluene µg/L	1,2,4,5-Tetrachlorobenzene µg/L	1,2,3,5-Tetrachlorobenzene µg/L	2,6-alpha-Trichlorotoluene µg/L	1,2,3,4-Tetrachlorobenzene µg/L	Pentachlorobenzene µg/L	Hexachlorobenzene µg/L	Octachlorostyrene µg/L	2,4,6-Trichlorophenol µg/L	2,4,5-Trichlorophenol µg/L	2,3,4-Trichlorophenol µg/L	2,3,5,6-Tetrachlorophenol µg/L	2,3,4,5-Tetrachlorophenol µg/L	Pentachlorophenol µg/L	Tetrachlorodibenzo -p-dioxins ng/L
Ballantrae Plaza	26/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Hutchinson	9/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
M.N.R.	23/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Fockler	9/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tranmer	23/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
Loughlan	30/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	
Detection Limits		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.2

nd = non-detectable

Table 16

Sample	Date Received	Trialkyl-/arylphosphates											Miscellaneous				
		Tri(butyl)phosphate µg/L	Tri(2-chloroethyl) phosphate µg/L	Tri(dichloropropyl) phosphate µg/L	Tri(phenyl)phosphate µg/L	Tri(butoxyethyl) phosphate µg/L	o-Isopropylphenyl-diphenylphosphate µg/L	Tri(o-tolyl)phosphate µg/L	Tri(m-tolyl)phosphate µg/L	Tri(p-tolyl)phosphate µg/L	p-tertbutylphenyl-diphenylphosphate µg/L	Tri(2,4-xylyl)phosphate µg/L	Methylene blue active substances (LAS) mg/L	Total phosphorus mg/L	Dissolved reactive phosphorus mg/L	Phosphates (FR) mg/L	Volatile acids mg/L
Ballantrae Plaza	26/01/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd					
Hutchinson	9/02/82	nd	nd	+	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd	24
M.N.R.	23/02/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		0.02	59
Fockler	9/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd	36
Tranmer	23/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.4		0.02	48
Coughlan	30/03/82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.02		nd	138
Detection Limits		This new methodology is still semi-quantitative. The single positive value (+) appears to be in the range 0.1-10 ppb. Method development is ongoing - see Appendix C for discussion.											0.1	0.02		0.02	10

nd = non-detectable

U = unfiltered F = filtered R = reactive T = total

Table 17

IMS - 491 Ballantrae Plaza 82/01/25

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

Volatiles	Concentration ug/L	Detection Limit
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	nd	5
3. t-1,2-Dichloroethylene	nd	1
4. 1,1-Dichloroethane	nd	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	nd	1
38. Di-n-Octyl Phthalate	nd	0.5
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	nd	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1

Table 17 cont.

IMS - 491 Ballantrae Plaza 82/01/25

Base/Neutrals	Concentration ug/L	Detection Limit
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Metals	Concentration mg/L	
Arsenic	nd	0.001
Cadmium	nd	0.0001
Chromium	0.002	0.0002
Copper	0.033	0.01
Lead	0.005	0.002
Mercury	nd	0.01 ug/L
Nickel	0.002	0.005
Selenium	not run	
Zinc	0.020	0.0001

Table 17 cont.

IMS - 491 Ballantrae Plaza 82/01/25

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters	Concentration mg/L	
Total Cyanide Free Cyanide	nd	0.005
Miscellaneous Total Phenols		

Table 18

IMS 502 - Hutchinson 82/02/08

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

Volatiles	Concentration ug/L	Detection Limit
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	nd	5
3. t-1,2-Dichloroethylene	nd	1
4. 1,1-Dichloroethane	nd	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	nd	1
38. Di-n-Octyl Phthalate	nd	0.5
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	nd	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1

Table 18 cont.

IMS 502 - Hutchinson 82/02/08

Base/Neutrals	Concentration ug/L	Detection Limit
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Metals	Concentration mg/L	
Arsenic		
Cadmium	0.003	0.0001
Chromium	0.004	0.0002
Copper	0.066	0.01
Lead	0.007	0.002
Mercury	nd	0.02 ug/L
Nickel	0.004	0.005
Selenium		
Zinc	0.081	0.0001

Table 18 cont.

IMS 502 - Hutchinson 82/02/08

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters	Concentration mg/L	
Total Cyanide		
Free Cyanide	nd	0.005
Miscellaneous Total Phenols		

Table 19

1MS 522 - M.N.R. Well 82/03/29

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

Volatiles	Approximate Concentration ug/L	Detection Limit
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	nd	5
3. t-1,2-Dichloroethylene	nd	1
4. 1,1-Dichloroethane	nd	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	T UCS	1
38. Di-n-Octyl Phthalate	nd	0.5

Table 19 cont.

1MS 522 - M.N.R. Well 82/03/29

Base Neutrals	Approximate Concentration ug/L	Detection Limit
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	T UCS	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Table 19 cont.

1MS 522 - M.N.R. Well 82/03/29

Metals		Concentration mg/L
Arsenic	0.004	0.001
Cadmium	nd	0.0001
Chromium	0.004	0.001
Copper	0.009	0.001
Lead	0.004	0.003
Mercury	nd	0.06 ug/L
Nickel	0.003	0.001
Selenium		
Zinc	nd	0.001

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters		Concentration mg/L
Total Cyanide	nd	
Free Cyanide	nd	0.005
Miscellaneous Total Phenols	nd	

Table 20

1MS 545 - Fockler Well 82/03/01

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

	Approximate Concentration ug/L	Detection Limit
Volatiles		
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	nd	5
3. t-1,2-Dichloroethylene	nd	1
4. 1,1-Dichloroethane	nd	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	trace UCS	1
38. Di-n-Octyl Phthalate	nd	0.5

Table 20 cont.

1MS 545 - Fockler Well 82/03/01

Base/Neutrals	Approximate Concentration ug/L	Detection Limit
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	nd	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Table 20 cont.

1MS 545 - Fockler Well 82/03/01

Metals		Concentration mg/L
Arsenic	nd	0.001
Cadmium	0.0001	0.0001
Chromium	0.004	0.001
Copper	0.056	0.001
Lead	nd	0.003
Mercury	nd	0.06 ug/L
Nickel	nd	0.001
Selenium		
Zinc	0.2	0.001

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters		Concentration mg/L
Total Cyanide	nd	
Free Cyanide	nd	0.005
Miscellaneous Total Phenols	nd	

Table 21

1MS 574 - Tranmer Well 82/03/22

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

Volatiles	Approximate Concentration ug/L	Detection Limit
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	nd	5
3. t-1,2-Dichloroethylene	nd	1
4. 1,1-Dichloroethane	nd	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	nd	1
38. Di-n-Octyl Phthalate	nd	0.5

Table 21 cont.

1MS 574 - Tranmer Well 82/03/22

Base/Neutrals	Approximate Concentration ug/L	Detection Limit
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	nd	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Table 21 cont.

1MS 574 - Tranmer Well 82/03/22

Metals		Concentration mg/L
Arsenic	nd	0.001
Cadmium	nd	0.0001
Chromium	0.004	0.001
Copper	0.014	0.001
Lead	0.005	0.003
Mercury	nd	0.06 ug/L
Nickel	nd	0.001
Selenium		
Zinc	0.18	0.001

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters		Concentration mg/L
Total Cyanide	nd	
Free Cyanide	nd	0.005
Miscellaneous Total Phenols	nd	

Table 22

1MS 577 - Coughlan Well 82/03/29

PRIORITY POLLUTANT SCAN FOR VOLATILES, ACID, BASE/NEUTRAL EXTRACTABLES, PESTICIDES PCB'S, METALS AND OTHER PARAMETERS

Volatiles	Approximate Concentration ug/L	Detection Limit
1. 1,1-Dichloroethylene	nd	1
2. Dichloromethane	13 ppb being re	5
3. t-1,2-Dichloroethylene	nd checked for	1
4. 1,1-Dichloroethane	nd lab contam	1
5. Chloroform	nd	1
6. 1,1,1-Trichloroethane	nd	1
7. 1,2-Dichloroethane	nd	1
8. Carbon Tetrachloride	nd	1
9. Benzene	nd	1
10. 1,2-Dichloropropane	nd	1
11. Trichloroethylene	nd	1
12. Bromodichloromethane	nd	1
13. Toluene	nd	1
14. 1,1,2-Trichloroethane	nd	1
15. Dibromochloromethane	nd	1
16. Tetrachloroethylene	nd	1
17. Chlorobenzene	nd	1
18. Ethyl Benzene	nd	1
19. m/p-xylene	nd	1
20. Bromoform	nd	1
21. o-xylene	nd	1
22. 1,1,2,2-Tetrachloroethane	nd	1
23. 1,4-Dichlorobenzene	nd	1
24. 1,3-Dichlorobenzene	nd	1
25. 1,2-Dichlorobenzene	nd	1
Base/Neutrals		
26. Hexachloroethane	nd	2
27. Hexachlorobutadiene	nd	2
28. Hexachlorobenzene	nd	2
29. 1,2,4-Trichlorobenzene	nd	1
30. Bis-(2-chloroethoxy)methane	nd	1
31. Naphthalene	nd	1
32. 2-Chloronaphthalene	nd	0.5
33. Nitrobenzene	nd	0.5
34. 2,4-Dinitrotoluene	nd	0.5
35. 2,6-Dinitrotoluene	nd	0.5
36. 4-Bromophenyl Phenyl Ether	nd	0.5
37. Bis-(2-Ethylhexyl) Phthalate	nd	1
38. Di-n-Octyl Phthalate	nd	0.5

Table 22 cont.

IMS 577 - Coughlan Well 82/03/29

Base/Neutrals	Approximate Concentration ug/L	Detection Limit
39. Di-methyl Phthalate	nd	1
40. Di Ethyl Phthalate	nd	1
41. Di n-Butyl Phthalate	nd	1
42. Butyl Benzyl Phthalate	nd	1
43. Acenaphthylene	nd	0.5
44. Acenaphthene	nd	1
45. Fluorene	nd	1
46. Fluoranthene	nd	1
47. Chrysene	nd	1
48. Pyrene	nd	1
49. Phenanthrene	nd	1
50. Anthracene	nd	1
51. Benzo(a)Anthracene	nd	1
52. Dibenzo(a,h)Anthracene	nd	6
53. Benzo(b)Fluoranthene	nd	1
54. Benzo(a)Pyrene	nd	1
55. Benzo(g,h,i)Perylene	nd	12
56. 4-Chlorophenyl Phenyl Ether	nd	
57. 1,2-Diphenyl Hydrazine	nd	1
58. N-Nitroso-Diphenylamine	nd	0.5
59. N-Nitroso-Dimethylamine	nd	0.5
60. N-Nitroso-Di-n-Propylamine	nd	0.5
61. Caffeine	nd	2
62. Nitrobenzene	nd	
63. Hexachlorocyclopentadiene	nd	2
64. Butoxyethoxyethanol	nd	1
65. Cholesterol	nd	10
66. p-Chloroaniline	nd	1
67. Benzothiazole	nd	0.5
68. Benzo(k)Fluoranthene	nd	6
Acids		
69. Hexadecanoic Acid	nd	6
70. Phenol	nd	1
71. 2-Nitrophenol	nd	3
72. 4-Nitrophenol	nd	6
73. 2,4-Dinitrophenol	nd	40
74. 4,6-Dinitro-o-Cresol	nd	6
75. p-Chloro-m-Cresol	nd	3
76. 2-Chloro Phenol	nd	1
77. 2,4-Dichlorophenol	nd	3
78. 2,4,6-Trichlorophenol	nd	3
79. 2,4-Dimethyl Phenol	nd	1
80. Pentachlorophenol	nd	6

Table 22 cont.

1MS 577 - Coughlan Well 82/03/29

Metals		Concentration mg/L
Arsenic	nd	0.001
Cadmium	nd	0.0001
Chromium	0.006	0.001
Copper	0.032	0.001
Lead	0.004	0.003
Mercury	nd	0.06 ug/L
Nickel	nd	0.001
Selenium		
Zinc	0.012	0.001

Pesticides PCB's	Concentration ng/L	Detection Limit
Arochlor 1016	nd	20
Arochlor 1221	nd	20
Arochlor 1242	nd	20
Arochlor 1248	nd	20
Arochlor 1254	nd	20
Arochlor 1260	nd	20
Hexachlorobenzene	nd	1
Heptachlor	nd	1
Aldrin	nd	1
4,4'-DDE	nd	1
Mirex	nd	5
Alpha BHC	nd	1
Beta BHC	nd	1
Gamma BHC (Lindane)	nd	1
Alpha Chlordane	nd	2
Gamma Chlordane	nd	2
Oxychlordane	nd	2
1,4'-DDT	nd	5
4,4'-DDD	nd	5
4,4'-DDT	nd	5
Methoxychlor (DMDT)	nd	4
Thiodan I	nd	2
Thiodan II	nd	4
Thiodan Sulfate	nd	4
Heptachlor Epoxide	nd	1
Dieldrin	nd	2
Endrin	nd	4

Other Parameters		Concentration mg/L
Total Cyanide	nd	
Free Cyanide	nd	0.005
Miscellaneous Total Phenols	nd	

Table 23

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
Benzene	22	0.1		1.4				0.1		
Toluene	328	0.1	1.4	0.9	0.4	0.2	0.1	0.3		0.3
Ethyl benzene	236			*	0.2	0.1		0.1		0.1
p-Xylene	174			2.6	0.3	0.1	0.1	0.1		0.1
o-Xylene	190									
m-Xylene	383				0.3	0.1	0.1	0.2		0.1
Cumene	7									
Styrene	6							0.1		0.1
1,1-Dichloroethane				2.1						
Methylene chloride	0.53									
Carbon tetrachloride	0.03									
Chloroform	0.01	0.1	0.1	0.1	0.1	0.1		0.1		
Trichloroethylene	0.30			0.2						
Tetrachloroethylene	0.09									
1,2-Dichloroethane				0.7						
Aroclor 1248	3000			25 ng/L (u)						
Octyldiphenylphosphate	*									
Tributyl phosphate	*									
Tri(chloroethyl)phosphate	*									
Tri(2,4-xylyl)phosphate	*									
C_{18} Benzene derivative	*									
C_{20} Benzene derivative	*									
Tetrachlorophenol	*									
Trichlorobiphenyl	*									
Tetrachlorobiphenyl	*									
Pentachlorobiphenyl	*									
Hexachlorobiphenyl	*									
Methyl ester benzoic acid	*									

Table 23 Cont'd.

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
Cholestadiene	*		0.1-0.25							
Dichlorobiphenyl	*									
Heptachlorobiphenyl	*									
Octachlorobiphenyl	*									
Nonachlorobiphenyl	*									
Dioctyl phthalate	*									
Benzylbutylphthalate	*		0.5-1							
Diethylphthalate	*							0.25		
C_4-Benzene	*									
C_5-Benzene	*									
Naphthalene	*	0.2								
Methyl naphthalene	*									
Dimethyl naphthalene	*									
Trimethyl naphthalene	*									
Phenanthrene	*									
Dimethylphenanthrene	*		0.5-1							
Methoxybiphenyl	*									
Substituted dihydroindene	*									
BHT	*		0.25-0.5							
Octyl phenol	*									
Ketone	*									
Esters of long chain acids	*	*	0.5-1	0.5-1	1		1	0.25	1	1
Dibutylphthalate	*									
Stearic acid	*									
Palmitic acid	*									
Methyl stearate	*									
Polyethylene glycol deriv.	*			150			1		1	1

Table 23 Cont'd.

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
Dimethylphthalate	*									
Butylmethylphthalate	*									
Pentachlorophenol		0.06	0.2 (u)	4.4						
Isopropanol		2.8	0.6							
Methylethyl ketone		1.2		0.4				0.1		
Diethyl ether		0.8	0.6	3.7		0.1				
Tetrahydrofuran		0.2								
Methyl isobutyl ketone		0.6			0.1		0.1			
Methylpentanol		0.2								
Octanoic acid		0.5-1		0.1-0.4						
Molecular sulfur		0.1-0.5		10						
Carboxylic acids		0.1	2.0	0.1-0.4			1		1	1
4-Butoxybutyric acid		0.1		2						
Cyclohexenecarboxylic acid deriv.				40,12						
Aliphatic alcohols		0.1	0.1-1	7	1	2	1	0.25	1	1
Aliphatic hydrocarbons		0.1	1-3	100		1	1	0.25	1	1
Butyl cellosolve methyl ether		0.1								
Ethyl cellosolve		0.1								
Cellosolve derivatives		0.1								
Pentaoxapentadecane		0.1								
Acetone								0.4		
beta-BHC			4 ng/L (u)							
alpha-BHC			1 ng/L (u)							
Phthalates							1		1	1
Di s-butyl azelaate			4							
Steroid			1							
6-Acetyl-2,5-dihydroxy-1,4-naphthoquinone			0.5-1							

Table 23 Cont'd.

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
Benzo-k-fluoranthene			0.25-0.5							1
Methyl phenanthrene			0.25-0.5							
Dodecyl perhydrophenanthrene			0.25-0.5							
Methyl dibenzothiophene			0.25-0.5							
Pentathiepane			0.25-0.5							
Dimethyl i-propylnaphthalene			0.1-0.25							
Dimethyl i-propyldecahydronaphthalene			0.1-0.25							
Cholestane			0.1-0.25							
Cholestadiene-one			0.1-0.25							
Butyl stearate			0.1-0.25							
Methyl benzamide			0.1-0.25							
Aliphatic ketones & aldehydes			0.1	5	1	1	1			1
7H-Indeno-anthracenone			0.1							
Diacetyl methoxybenzofuran			0.1							
Butyl butyrate			0.1							
Isopropyl benzoate			0.1	15						
Trans-1-2-dichloroethylene			2.0							
Methyl styrene			1.1				1			
Dihydroisophorone				200						
Isophorone				22						
Isophorone isomer				40						
Menthol				17						
Carvomenthol				13						
Xylenol				30						
Ethyl carbitol ethyl ether				50						
Toluene sulfonamide				50						
Fenchone				25						
Steroid				15		1	1	0.25	1	

Table 23 Cont'd.

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
3-Methyl-2,6-dioxohexenoic acid				20						
Polyglycols				10						
Octanedione				9						
Tetrahydrohexamethyl-s-indacene-dione				9						
Dimethyloctalone				6						
1-Benzoyl-1-s-butyl acetone				3						
Propylene glycol				9						
Resin acid				4						
Ethyl esters				2						
Camphor				8						
Hydroxyoctalone				1						
Dimethylamino-propenylidene-benzofuranone				3						
Propenyl benzoate				2						
S-Methyl-thioanisoate				1						
6-Methyl-6-azobicyclooctanone				0.5-1						
Dimethylphthalic anhydride				0.5-1						
Propenylidene benzofuranone-cyclohexanone derivative				0.5-1						
Dimethyl benzoic acid				0.5-1						
p-t-Butyl benzoic acid				0.5-1						
2-Hexyl-1-methyl pyrrolidine				0.5-1						
Phthalic anhydride				0.1-0.4						
Primidone				0.1-0.4						
Hydroxy-i-propylacetophenone				0.1-0.4						
S-containing							1			
1,1,1-Trichloroethane					0.1					

Table 23 Cont'd.

Summary of Organics Identified and Concentrations Calculated or Estimated

Compounds	LW5 mg/L	2-75 ug/L	16-70 ug/L	1-80 ug/L	BP ug/L	Hutchinson ug/L	M.N.R. ug/L	Fockler ug/L	Tranmer ug/L	Coughlan ug/L
C_3benzene					0.1			0.1		
N-containing							1			
Trimethoxybenzene					1					
Thioacetic acid derivative					1					
Caffeine derivative					1					
Benzopyrene					1					
Polycyclic aromatic ketones					1					
Dibenzyl					1					
Naphthylamine					1					1
Amides					1				1	1
Resorcyl aldehyde derivative					1					
Food preservatives						1		0.25	1	
Tri(dichloropropyl)phosphate						1				
Hexane							0.1			
Nicotine									1	1
PAH's									1	
Terpenoid type									1	
Dimethylbenzylamine										3
Phenol derivatives										1
Furanone derivatives										1
1,1'-(1-methylene-1,2-ethanediyl)-bis-4-methoxy benzene										1
Naphthalene derivative										1

Key: * Identified, not quantitated
(u) unfiltered
B.P. Ballantrae Plaza

B. OUTLINE OF SUPPLEMENTARY ANALYTICAL METHODS

B. OUTLINE OF SUPPLEMENTARY ANALYTICAL METHODS

The analytical methods used in the organics profiling of the on-site and off-site wells sampled in this study are described in the body of this report (see sections IV A and V A). The following is a brief outline of the additional parameters tested and methods applied in characterising these wells and includes the other class-specific scans for herbicides and pesticides, metals, general water quality parameters and microbiological analyses.

1) Other Class-Specific Scans

a) Organophosphate Pesticides

This class of compounds comprises a series of organic esters of phosphorus-based acids. Organophosphate pesticides have gained widespread usage in orchards, nurseries and greenhouses. Because of their low persistence and high effectiveness, they are now used worldwide.

They are highly neurotoxic, causing deactivation of the enzyme cholinesterase in the body. However, due to their relatively high water solubility and ease of hydrolytic breakdown, they are not stable or persistent.

Trace concentrations might be expected in leachates from landfill sites which have received old containers or waste formulations.

Analysis is normally accomplished using solvent extraction, concentration and gas chromatography equipped with highly specific phosphorus and sulphur sensitized detectors. Detection limits in water range from 0.01 to 1.0 ug/L.

b) Organochlorine Pesticides

This class of pesticides are mostly chlorinated derivatives of various cyclic hydrocarbons. Their chemical makeup makes them highly resistant to environmental degradation and therefore, very persistent. Water solubility of these compounds is very low, but lipid solubility is high, making them liable to rapid bioconcentration. The acute toxicity of most organochloride pesticides is low, but the fact that some have been shown to be carcinogens, together with their

persistence and bioaccumulation has lead to the banning of most uses for this class of materials. Some members of this class could contribute to positive results during mutagen testing (Ames test, etc.).

Organochlorine residues in old bags, drums or waste formulations may have been disposed of in landfill sites. These materials can migrate in leachates if adsorbed on microparticulates or solubilized by other organics.

Testing is carried out by solvent extraction, concentration and chromatographic clean-up followed by high sensitivity, high specificity electron capture gas chromatography. The method has a routine detection limit ranging from 0.001 - 0.005 ug/L for water samples.

c) Chlorophenoxy Acid Herbicides

Chlorophenoxy acids herbicides (2,4-D type) are widely used for selective weed control in crops that are comparatively resistant to these chemicals, for the control of roadside vegetation and for home lawn care. These herbicides may also be used for the control of some aquatic plants. Potential problems occur when agricultural run-off waters containing 2,4-D type residues are used to irrigate a crop which is more susceptible to such residues, thus causing serious damage. These materials can also impart severe taste and odour problems to water supplies at low mg/L levels. Part of the taste problems arise from the ability of the herbicides to decompose to chlorophenols which may also be present as impurities in the herbicide.

Although the toxicity of 2,4-D type herbicides to mammals is relatively low, impurities (such as dioxins) which are produced as by-products in the manufacture of these herbicides are extremely toxic. Such impurities may cause birth defects.

Again, the presence of chlorophenoxy acid herbicides in landfills would probably be caused by disposal of old containers or formulations. These compounds, especially the free acids and salts, are relatively water soluble and more likely to migrate with leach waters than compounds like PCBs which have low solubilities. Testing is carried out by solvent extraction, conversion of acids to volatile methyl esters, and analysis by capillary electron capture gas chromatography. Detection limits range from 0.05 to 0.2 ug/L.

d) Triazine Herbicides

This class of herbicides is in widespread use for protection of various crops. Triazine herbicides are heavily used on corn fields, and also for industrial weed and brush control. These herbicides are aromatic ring compounds with ring and side chain nitrogen substitution. They are relatively persistent in soil although detoxification may occur through microbial degradation. These compounds appear to exhibit low toxicity to humans.

Triazine formulations or old herbicide containers may have been disposed of in landfill sites. These compounds could migrate into leachates if they were adsorbed on particulates. The rate of triazine degradation in "soil" would depend on temperature, pH, etc.

Testing is performed by solvent extraction, concentration and chromatographic clean-up followed by gas chromatography with a Nitrogen-specific detector. The routine detection limit in water is 0.05 - 0.1 ug/L.

e) Chlorinated Benzenes and Related Compounds

These compounds are frequently used industrial materials. They are used in synthesis, as solvents for moth proofing, household disinfectants, and as diluents for PCBs. They are also produced as degradation products in the pyrolysis of other chlorinated organics, or as byproducts in synthetic reactions. Hexachlorobenzene has been used extensively as a fungicide in wheat. Chlorinated benzenes are relatively stable and related classes have fairly low water solubility, and can rapidly bioaccumulate. They have fairly high environmental stability.

Chlorinated benzenes, especially HCB, show significant toxic effects. Reports on damage to bone marrow, as well as studies on mutagenicity, teratogenicity and carcinogenicity are available.

Their presence in industrial wastes and waste treatment processes, and as byproducts make their presence in industrial chemical landfills possible.

Testing is normally carried out by solvent extraction, concentration and chromatographic clean-up followed by capillary electron capture gas chromatography. Detection limits are 0.05 ug/L.

f) Chlorophenols

Chlorophenols are hydroxy derivatives of chlorobenzenes. They are acidic and water soluble, especially as their alkali metal (Na, K) salts. Chlorophenols have wide usage as germicides, insecticides and fungicides and are also used as flea repellents and wood preservatives. They can contain dioxins and dibenzofuran as trace impurities. Chlorophenols have also been used as herbicides and in industrial synthesis and can be produced during the incineration of chlorinated organics.

Chlorophenols are toxic to mammals and fish, the toxicity varying from compound to compound. They can cause significant taste and odour problems in drinking water at levels as low as 1 ug/L. The maximum desirable drinking water concentration of phenols in general is 2 ug/L. The levels for specific chlorophenols may well be lower than this figure.

Their presence in herbicides and industrial wastes makes chlorophenols a potential candidate class for pollution from landfill sites. Their relative persistence and water solubility indicate that they could easily leach and migrate off-site in any contaminated groundwater plume.

Testing is carried out by solvent extraction under acid conditions, conversion of phenols to volatile methyl ethers, then analysis by capillary electron capture gas chromatography. Detection limits range between 0.05 and 0.1 ug/L.

g) Tetrachlorodibenzo-p-dioxins (TCDDs)

The class of compounds referred to as tetrachlorodibenzo-p-dioxins (TCDDs) is a sub-group of the general polychlorinated dibenzodioxin family (PCDD). TCDDs contain four chlorine atoms arranged around a dioxin nucleus. Various individual arrangements of the four chlorine atoms allow for 22 possible TCDD configurations.

All 22 TCDDs are known to be chronically and acutely toxic, with 2,3,7,8-tetrachlorodibenzo-p-dioxin specifically being characterized as the most toxic man-made chemical. TCDDs are chemically inert, making them relatively resistant to environmental degradation. The water solubility of these compounds is

low. They can rapidly bioaccumulate by a factor of 10,000. These compounds are known carcinogens and mutagens, and have been shown to enhance these types of responses in other chemicals.

TCDDs are never synthesised intentionally. They are trace level (parts per million) by-products of the manufacture of certain herbicides, such as 2,4,5-T. Waste herbicide formulations or containers may have been disposed of in some landfill sites. These compounds are strongly adsorbed to particulate material and can migrate in leachates on microparticulates. They could also migrate if solubilized by other organics.

Testing is carried out by capillary gas chromatography/mass spectrometry, which provides uniquivocal evidence of their presence or absence. The method has a detection limit of 0.2 ppt for TCDD in water. The results are reported as total tetrachlorodibenzodioxins. There are no current Ontario drinking water criteria for dioxins.

2) Metals

Metals are a natural part of the earth's crust and can be found in measurable quantities in practically every living and inanimate substance in the world. Metals constitute about five percent of the earth's rocks and are sufficiently soluble to have been distributed, over the millenia, into every part of the environment.

Man's activities have upset this natural, ubiquitous distribution of metals in the environment. Mining, smelting, plating, metal fabrication and energy-production are the primary activities that release more than natural levels of metals to the environment. Generally, all wastes that are disposed of by land-filling will contain metals.

Metal-containing wastes can vary widely in solubility in a landfill environment. Factors such as permeability, particle size and surface area, mineral composition and degree of crystallinity, pH and organic content of the leaching medium, all have roles in the mobilization process. Most metals tend to become more soluble in an acidic medium, thus acid rain may have a subtle but increasingly important impact. Some metals, such as copper, form soluble organic complexes. Most

metals can be immobilized by precipitation through the formation of hydroxides, carbonates, sulphides and phosphates in basic media. Arsenic can precipitate out by combination with iron. The soils and rocks surrounding a disposal site can provide a filtration mechanism restricting the movement of water-borne particles and can remove metals in solution by cation exchange and chemical combination.

Water samples from monitoring and drinking water wells, as well as waste materials are analyzed for metals by atomic absorption spectrophotometry and by emission spectrometry-inductively coupled argon plasma. Samples are prepared by digestion with mineral acids. Arsenic is determined by flameless atomic absorption spectrophotometry following generation of the hydride.

Detection limits using these techniques are in the range 0.5 to 5 ug/L.

The 1978 Federal Health and Welfare "Guidelines for Canadian Drinking Water Quality" provide the following recommended limits for chemical substances related to health:

Metal	Maximum Acceptable Concentration (mg/L)	Objective Conc. (mg/L)
Arsenic	0.05	0.005
Barium	1.0	0.1
Cadmium	0.005	0.001
Chromium	0.05	0.002
Lead	0.05	0.001
Mercury	0.001	0.0002
Selenium	0.01	0.002
Silver	0.05	0.005
Uranium	0.02	0.001

The same document lists the following limits related to aesthetic and other considerations:

Copper	1.0	1.0
Iron	0.3	0.05
Manganese	0.05	0.01
Zinc	5.0	5.0

3) General Water Quality Parameters

As part of the Ministry of the Environment's Water Management goals, policies and objectives, certain drinking water quality criteria have been established within the Province. An extensive list of general water quality parameters is routinely used to "classify" a drinking water supply. The majority of the parameters included in this list are naturally occurring and are present in all water supplies at varying levels. Modern water treatment techniques and a wide variety of available water treatment processes make posssible the use of raw water of varying quality to produce an acceptable public water supply. Water quality recommendations are those limits of characteristics and concentrations of substances in raw waters that will allow the production of a safe, clear, potable, aesthetically pleasing and acceptable public water supply.

Drinking water shall not contain impurities in concentrations that may be hazardous to the health of the consumers. It should not be excessively corrosive to the water-supply system. Substances used in its treatment should not remain in the water in concentrations greater than required by good practice. Substances that may have deleterious physiological effects, or substances for which physiological effects are not known, should not be introduced into the system in a manner that would permit them to reach the consumer.

Limits are specified on the basis of two considerations, namely, health and aesthetics, as follows:

> **Health:** These limits apply to certain substances that are known or suspected to have adverse health effects.
>
> **Aesthetics:** These limits apply to certain substances or conditions, the presence of which in excess of these limits in water does not present a risk to human health, but may render the water unpalatable or otherwise unacceptable to the consumer.

In the case of physical and chemical characteristics, two types of limits have been established:

> **Maximum Acceptable:** Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.

Objective: This level is interpreted as the ultimate quality goal for both health and aesthetic purposes, i.e., maximum desirable.

The table below lists the important general water quality parameters along with available Ontario drinking water quality criteria or limits based on the considerations discussed previously:

Parameter	Criteria	Specification
Calcium as Ca	--	
Magnesium as Mg	--	
Hardness as $CaCO_3$	500 mg/L	Maximum desirable (aesthetics)
Iron as Fe	0.3 mg/L	"
Chloride as Cl	250 mg/L	"
pH (range)	6.5 to 8.5	"
Conductivity	--	--
Sodium as Na*	--	--
Free Ammonia as N	--	--
Total Kjeldahl as N	--	--
Dissolved organic carbon	--	--
Dissolved inorganic carbon	--	--
Phenol	2 ug/L	Maximum desirable (aesthetics)
Chemical oxygen demand	--	--
Manganese as Mn	0.05 mg/L	Maximum desirable (aesthetics)
Sulphate as SO_4	250 mg/L	"
Potassium as K	--	--
Nitrite nitrogen as N**	1.0 mg/L	Maximum acceptable (health)
Nitrate nitrogen as N**	10.0 mg/L	"

* Water containing more than 20 mg/L sodium should not be consumed by those people on a sodium-restricted diet. Appropriate health authorities should be notified if a water supply exceeds this level.

** Where both nitrite and nitrate are present, the total nitrite plus nitrate-nitrogen should not exceed 10 mg/L.

4) Microbiological Analyses

The coliform group (TC) of bacteria has, for many years, been used as the main bacterial indicator of polluted water (drinking or bathing), although other groups are used to further define the degree of impairment. The TC count is used in conjunction with the level of background organisms. Those coliforms known to be present in the gut or feces of warm blooded animals are termed fecal coliforms (FC) and can be detected using an elevated incubation temperature of 44.5°C. Escherichia coli is generally the predominant organism in this group. A third indicator group, fecal streptococci (FS), comprises several species belonging to the genus Streptococcus. In conjunction with the FC parameter, the FS count will provide an FC/FS ratio which indicates the nature of the fecal source. Other specific bacteria for which enumeration or isolation methods are available include Escherichia coli, Klebsiella, Pseudomonas aeruginosa and Salmonella.

Each of the above parameters can be determined by the membrane filter technique which provides a direct plating for the detection and quantitation of bacterial densities in a given volume of water.

A fourth indicator group is comprised of heterotrophic bacteria (HB). This parameter is designed to enumerate as large a number as possible of those bacteria in water that require some organic carbon for their growth. The HB count at 20°C is used to indicate the trophic status of surface waters and is affected by levels of organic and inorganic nutrients. Analysis is by the spot or spread plate. At 35°C, the HB parameter measures treatment efficiencies for treated drinking water, or general bacterial water quality in untreated well water. Membrane filtration is used to analyse for HB at 35°C.

An alternative to the membrane filtration procedure is the Presence-Absence (P-A) method which provides a sensitive means of detecting pollution indicator bacteria in drinking water samples. Essentially, the P-A test is a modification of the most probable number (MPN) procedure which uses a dilution series of broth tubes to detect and enumerate microorganisms. The test allows for an inoculum of up to 100 mL and will qualitatively determine a wide variety of bacteria, including TC, FC, FS, Pseudomonas aeruginosa, Staphylococcus aureus, Aeromonas and Clostridium perfringens.

Certain microorganisms, although not pathogenic or indicative of the presence of fecal material, may be related to a deterioration in water quality. Foul tastes and odours, slimes, discolouration, and the clogging or corrosion of treatment or distribution systems may all result from the presence of such "nuisance" organisms. Included in this category are iron bacteria such as Gallionella, Leptothrix, Sphaerotilulus and Crenothrix, the sulphate-reducing bacteria of the genera Desulphovibrio and Desulphotomaculum, the sulphur oxidizer Beggiatoa, actinomycetes, algae and fungi. Generally, identification of these organisms is based upon direct microscopic observation of the sample.

The TC, FC and FS groups, and specific pathogens such as Pseudomonas aeruginosa should not be present in water used for human or animal consumption. While the objective level for TC should be no organisms detectable per 100 mL, in practice this level is not always attainable. A level up to 10 TC/100 mL is considered safe for drinking if this remains stable and the supply is protected and located at least 100 feet from any source of human or animal wastes. Also, the level of background organisms should not exceed 1000 bacteria/100 mL.

C. PHOSPHATE ESTER CONTAMINATION

C. PHOSPHATE ESTER CONTAMINATION

The analysis of the on-site observation wells OW 16-70, OW 2-75 and OW 1-80 by gas chromatography using a nitrogen/phosphorus specific detector indicated the presence of trialkyl, aryl-alkyl and triaryl phosphate esters. For each observation well analysed, an identical chromatographic profile was obtained when using the element selective nitrogen/phosphorus detector.

An investigation of the potential source of these compounds indicated that the insulated rubber gloves used by the samplers were contaminating the samples. It was due to glove contact with the sample bailer during the transfer stage of the sampling procedure, resulting in contamination of the observation well. The analysis of a leachate of the actual gloves used during the sampling, together with a similar yet "unused" glove, indicated the same profile for phosphate esters as was obtained from the observation well samples.

The on-site observation wells, OW 16-70, OW 2-75 and OW 1-80 were resampled using latex and cotton gloves instead of the previously used insulated industrial gloves. The gas chromatographic analysis of the sample extracts indicated the presence of phosphate esters at much lower concentrations than previously detected.

Additional resampling of the observation wells indicated the presence of phosphate esters at similar concentrations to those found in the repeat sampling.

It would appear that the presence of the phosphate esters in the observation wells was due to external contamination by the samplers and did not originate from the landfill site.

D. GC/MS ANALYSIS BY MANN TESTING LABORATORY ON BALLANTRAE PLAZA AND HUTCHINSON WELLS

MANN TESTING LABORATORIES LTD.,
80 GALAXY BLVD., UNIT 10,
REXDALE, ONTARIO
M9W 4Y8
PHONE: 675-3598
TELEX: 06-989502

March 3, 1982

M. Glenys Foster, M.Sc.
Chief, Mass Spectrometry Services
Organic Trace Contaminants Section
Laboratory Services Branch
Ministry of the Environment
P.O. Box 213
Rexdale, Ontario
M9W 5L1

Dear Ms Foster:

RE: Lab. No. 820107

Samples from Test Wells #1 and #2 were delivered to this laboratory by yourself on Friday, February 12, 1982 and analysed in accordance with your quality assurance protocols, a copy of which is attached. Ordinary tap water was used as a control. Deuterated internal standards were added to all samples including the control.

The analysis protocol followed closely the procedures established by the United States EPA. Three fractions of each samples were prepared and analysed by the GC/Mass Spectrometry--

1. Purge and trap fraction for volatiles
2. Base-neutral fraction
3. Acid fraction

The detection limit for all fractions was 1 ug/l or better. The GC/MS output was by the Finnigan Incos Data System based on the NBS library of approximately 31000 compounds. Manual examination was performed on all data output. The reports are attached for your persual.

In general the levels of contaminants were very low. Phthalates were determined at the 1 ppb level however they can not be attributed conclusively to the water sample. These substances (plasticizers) are very common and appear constantly in our extractions. Similarly methylene chloride was found by purge and trap methods at the 100 ppb level. Methylene chloride is our most common laboratory solvent. It generally appears in samples at the 20 ppb level with a 5 ml purge. It is conceivable that with the 25 ml purge, as used for these tests, that the 100 ppb level is not unexpected.

Due to the sensitivity of these samples we conducted additional work. The acid extracts were methylated with diazomethane and again analysed by GC/MS. Base-neutral and acid extracts were screened by GC through an OV-17 packed column and an electron capture detector. No additional information was obtained from these tests.

Resin acids were not detected in our extracts except for a trace of 1-phenanthrene carboxylic acid-octahydro-dimethyl.

The presence of toxic organic compounds would have been detected by our tests if they were in excess of 1 ug/l.

All data will be stored on the computer until March 30, 1982. Please let me know if you wish further information or require additional confirmatory testing.

Yours truly,

MANN TESTING LABORATORIES LTD.

John W. Martin,P.Eng.
Vice President

JWM/rc

Att.

ANALYTIC PROCEDURE REPORT

STOUFFVILLE SAMPLES & TAP WATER BLANKS

A) Purgeables/Volatiles

Twenty-five millilitres of water was spiked with 100 nanograms of deuterated chlorobenzene, (C_6D_5Cl) to 4 ppb. The mixture was then sparged for 20 minutes on the concentrator. The concentrate was then back flushed onto a 50 metre Carbowax 20 M capillary column and the eluants analysed by mass spectrometry. A Finnigan 3200 MS was used in conjunction with the Incos Data system of the Finnigan 4023 MS.

B) Extractables

Fifteen hundred millilitres of water was spiked with fifteen micrograms of deuterated anthracene ($C_{14}D_{10}$) to 10 ppb. The water was made alkaline (pH 12) with 6N NaOH and extracted three times with methylene chloride (200 ml, 100 ml, 50 ml). The organic fraction was roto-evaporated and labelled "Base-neutral extract".

The alkaline water was made acidic (pH 2) with 6N HCl and spiked with fifteen micrograms of deuterated anthracene. The water was extracted three times with methylene chloride (200 ml, 100 ml, 50 ml). The organic fraction was roto-evaporated and labelled "Acid extract".

The extracts were analyzed by GC/MS on the Finnigan 4023 with the Incos Data System. One microlitre of two hundred

microlitres of each extract was injected splitless onto a 30 metre DB-5 capillary column with a head pressure of 15 psi. The oven temperature was programmed from 30°C to 280°C @ 6°C/min. The mass range of 34-450 amu was scanned once per second.

C) Recovery Study

The following compounds were spiked to 10 ppb in pre-cleaned water and extracted and analysed in an identical manner to the proceeding samples:-

1. Phenol (BP94)..... 74%
2. Chloromethyl phenol (BP107).....123%
3. n-Octylphthalate (BP149).....103%
4. i-Octylphthalate (BP149).....103%
5. Dl0-anthracene (BP188)..... 74%
6. Benzo (k) fluranthene (BP252)..... 96%

DATE: ~~March 3, 1982~~ SAMPLE DESCRIPTION: Stouffville Water Sample

SAMPLE: Test Well #1

ORIGINAL VOL/WEIGHT: 1500 mls. SUBMITTED BY: G. Foster PROJECT # 820107 QUANTITATION BY: XXGC-MS EC FID

COMPOUND	AMOUNT
PURGEABLE GROUP	
Benzene	
Bromodichloromethane	
Bromoform	
Carbon tetrachloride	
Chlorobenzene	
Chloroform	
Dibromochloromethane and/or Cis-1,3dichloropropene	
1,1-Dichloroethane	
1,2-Dichloroethane	
1,1-Dichloroethylene	
Trans-1,2-dichloroethylene	
1,2-Dichloropropane	
Trans-1,3-dichloropropene	
Ethylbenzene	
Dichloromethane	* 129 ppb
1,1,2,2-Tetrachloroethane and/or 1,1,2,2-Tetrachloroethene	
Toluene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane and/or Trichloroethylene	
Trichlorofluoromethane	
ACID GROUP	
p-Chloro-m-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-o-cresol	
2,4-Dinitrophenol	
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	
2,4,6-trichlorophenol	

COMPOUND	AMOUNT
BASE NEUTRAL GROUP	
Polynuclear Aromatics:	
Acenaphthene	
Acenaphthylene	
Anthracene and/or Phenanthrene	
Benzo(a)anthracene and/or Chrysene	
Benzo(b)fluoranthene and/or Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Dibenzo(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	
Pyrene	
Chlorinated Benzenes:	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene and/or 1,4-Dichlorobenzene	
1,2,4-Trichlorobenzene	
Hexachlorobenzene	
Nitrosamines:	
N-nitrosodimethylamine	
N-nitrosodiphenylamine	
N-nitrosodi-n-propylamine	
Phthalate Esters:	
Butyl benzylphthalate	
Di-n-butylphthalate	0.57 ppb
Diethylphthalate	
Dimethylphthalate	
Di-n-octylphthalate	

COMPOUND	AMOUNT
Bis-(2-ethylhexyl)phthalate	0.22 ppb
Haloethers:	
4-Bromophenyl phenyl ether	
Bjs(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	
Bis(2-chloroisopropyl)ether	
4-Chlorophenyl phenyl ether	
Other Compounds:	
Benzidine	
2-Chloronaphthalene	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Hexachlorobutadiene	
Hexachlorocylcopentadiene	
Hexachloroethane	
Isophorone	
Nitrobenzene	
PESTICIDE GROUP	
Aldrin	
alpha-BHC	
beta-BHC	
gamma-BHC(Lindane)	
delta-BHC	
Chlordane	
4,4'-DDD	
4,4'-DDT	
alpha-Endosulfan	
beta-Endosulfan	
Endosulfan Sulphate	
Endrin	
Endrin aldehyde	
Heptachlor	
Heptachlor epoxide	
PCB's	
Toxaphene	
Dieldrin	
4,4'-DDE	

OTHERS	
C5-Phenol	0.07 ppb
Phenyl compound (2)	0.09 ppb

COMMENTS:

* Suspected Lab contamination during sample handling

DATE: March 2, 1982 SAMPLE DESCRIPTION: Stouffville Water Sample

SAMPLE: Test Well #2

ORIGINAL VOL/WEIGHT: 1500 ml SUBMITTED BY: G. Foster PROJECT # 820107 QUANTITATION BY: xxGC-MS EC FID

COMPOUND	AMOUNT
PURGEABLE GROUP	
Benzene	
Bromodichloromethane	
Bromoform	
Carbon tetrachloride	
Chlorobenzene	
Chloroform	
Dibromochloromethane and/or Cis-1,3dichloropropene	
1,1-Dichloroethane	
1,2-Dichloroethane	
1,1-Dichloroethylene	
Trans-1,2-dichloroethylene	
1,2-Dichloropropane	
Trans-1,3-dichloropropene	
Ethylbenzene	
Dichloromethane	* 86 ppb
1,1,2,2-Tetrachloroethane and/or 1,1,2,2-Tetrachloroethene	
Toluene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane and/or Trichloroethylene	
Trichlorofluoromethane	
ACID GROUP	
p-Chloro-m-cresol	
2-Chlorophenol	
2,4-Dichlorophenol	
2,4-Dimethylphenol	
4,6-Dinitro-o-cresol	
2,4-Dinitrophenol	
2-Nitrophenol	
4-Nitrophenol	
Pentachlorophenol	
Phenol	0.03 ppb
2,4,6-trichlorophenol	

COMPOUND	AMOUNT
BASE NEUTRAL GROUP	
Polynuclear Aromatics:	
Acenaphthene	
Acenaphthylene	
Anthracene and/or Phenanthrene	
Benzo(a)anthracene and/or Chrysene	
Benzo(b)fluoranthene and/or Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Dibenzo(ah)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	
Pyrene	
Chlorinated Benzenes:	
1,2-Dichlorobenzene	
1,3-Dichlorobenzene and/or 1,4-Dichlorobenzene	
1,2,4-Trichlorobenzene	
Hexachlorobenzene	
Nitrosamines:	
N-nitrosodimethylamine	
N-nitrosodiphenylamine	
N-nitrosodi-n-propylamine	
Phthalate Esters:	
Butyl benzylphthalate	
Di-n-butylphthalate	0.97 ppb
Diethylphthalate	
Dimethylphthalate	
Di-n-octylphthalate	

COMPOUND	AMOUNT
Bis-(2-ethylhexyl)phthalate	0.99 ppb
Haloethers:	
4-Bromophenyl phenyl ether	
Bjs(2-chloroethoxy)methane	
Bis(2-chloroethyl)ether	
Bis(2-chloroisopropyl)ether	
4-Chlorophenyl phenyl ether	
Other Compounds:	
Benzidine	
2-Chloronaphthalene	
3,3'-Dichlorobenzidine	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
1,2-Diphenylhydrazine	
Hexachlorobutadiene	
Hexachlorocylcopentadiene	
Hexachloroethane	
Isophorone	
Nitrobenzene	
PESTICIDE GROUP	
Aldrin	
alpha-BHC	
beta-BHC	
gamma-BHC(Lindane)	
delta-BHC	
Chlordane	
4,4'-DDD	
4,4'-DDT	
alpha-Endosulfan	
beta-Endosulfan	
Endosulfan sulphate	
Endrin	
Endrin aldehyde	
Heptachlor	
Heptachlor epoxide	
PCB's	
Toxaphene	
Dieldrin	
4,4'-DDE	

OTHERS	
C_5-Phenol	0.33 ppb
Phenyl compound (?)	0.04 ppb

COMMENTS:

* Suspected Lab contamination during sample handling

E. CONCENTRATION AND HPLC ANALYSIS BY ONTARIO RESEARCH FOUNDATION ON HUTCHINSON AND M.N.R. WELLS

ONTARIO RESEARCH FOUNDATION

SHERIDAN PARK RESEARCH COMMUNITY

MISSISSAUGA, ONTARIO, CANADA L5K 1B3 • (416) 822-4111 • TELEX 06-982311

Ministry of the Environment,
Laboratory Services Branch,
Resources Road, Box 213,
Rexdale, Ontario.
M9W 5L1

May 31, 1982

Attention: Dr. G. Foster.

REPORT NUMBER ACS4-82233

IDENTIFICATION A71739E

SPECIFICATIONS OF ORDER Concentration, fractionation and SE HPLC analysis of 2 (two) Stoufville water samples.

The Ontario Research Foundation has been involved in a research program directed at methods development of procedures for the concentration and characterization of organic chemicals in drinking water supplies. One aspect of this program focuses on procedures to concentrate and fractionate the high molecular weight, non-volatile, polar organic compounds present in such waters (e.g. humic/fulvic acid). The samples used in the study were drinking water concentrates (DWC) obtained by vacuum distillation of large volumes of water followed by freeze drying. The freeze dried material was then processed using the procedure shown schematically in Figure 1. Total organic carbon (TOC) was the principal analytical tool used for monitoring the extent of fractionation. Adsorption/desorption studies on accumulator columns of XAD-2 in tandem with XE-340 resulted in 70 - 75% and 18 - 20% recoveries of TOC respectively. The fractions collected were analysed by a TSK gel-size exclusion HPLC (SE HPLC)-UV/fluorescense technique. In general, the TSK gel SE HPLC of the XAD-2 and XE-340 extracts indicated

the presence of molecular size fractions with a molecular weight distribution between 3,000 - 14,000. The claimed exclusion limit of the TSK gel used for size exclusion studies is 2×10^4 MW.

The two 20 litre Stoufville water samples were concentrated by vacuum distillation to about 2 litres and the concentrates were then freeze-dried. The yields of the residue were 9.5 g and 6.8 g from Sample 1 and Sample 2 respectively.

For the SE HPLC profiling of high molecular weight (MW) organics, e.g. humic/fulvic acids in the water samples, the freeze-dried residues were processed according to the fractionation scheme shown in the flow sheet in Figure 1. 7.0 g freeze-dried residue from Sample 1 (equivalent to ∿15 litres of water) and 5.0 g residue from Sample 2 (equivalent to ∿15 litres) were fractionated and the fractions were analysed for humic/fulvic acid by SE HPLC.

The chromatographic conditions used are as follows:

Column: 2 columns (7.5 mm x 60 cm each), 10 µm, µSpherogel TSK SW2000 (exclusion limit 2×10^4)

Mobile phase: 0.01 M TRIS, pH 7.2

Flow rate: 1.0 mL/min or 1.5 mL/min

Temp: Ambient

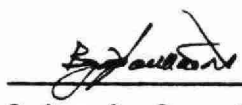
Detector: UV @ 254 nm

Injection: 20 µL or 50 µL

The TSK gel-SE HPLC of both XAD-2 resin and XE-340 resin extracts of the water Sample 1 showed the presence of three size fractions with a molecular weight distribution ranging between 10,000 - 16,000 MW. The XAD-2 extracts of water Sample 2 also showed three molecular size fractions with a molecular weight distribution ranging between 11,500 - 17,000 MW. The approximate molecular weights of the TSK gel SE HPLC fractions were obtained using a calibration curve (Figure 2) prepared from PEG molecular weight standards. The results are shown in Table 1. The results indicate that the two Stoufville water samples contain high molecular weight organic compounds

similar to those observed in other drinking water supplies, e.g. Lakeview and Brantford. The apparent differences in the molecular weights of the three size fractions observed between the two Stoufville water samples are probably due to the following. Sample 1 was analysed using the calibration standard prepared on the same day. The calibration standard was not rerun to analyse Sample 2. The calibration data as used with Sample 1, was used to determine the molecular weight of the fractions in Sample 2 which had been processed and run on a different day (2 weeks later). This fact is probably responsible for the observed differences in the elution volumes in SE HPLC, resulting in the above molecular weight differences. Therefore, no significance should be attributed to the apparent molecular weight differences between the two samples. The following SE HPLC chromatograms of the sample fractions are included in the report.

Figure 3 Fraction B of Water Sample 1 (1.0 mL/min flowrate)
Figure 3A Fraction B of Water Sample 1 (1.5 mL/min)
Figure 4 Fraction B' of Water Sample 1 (1.0 mL/min)
Figure 4A Fraction B' of Water Sample 1 (1.5 mL/min)
Figure 5 Fraction D of Water Sample 1 (1.5 mL/min)
Figure 6 Fraction D' of Water Sample 1 (1.5 mL/min)
Figure 7 Fraction E of Water Sample 1 (1.5 mL/min)
Figure 8 Fraction E' of Water Sample 1 (1.5 mL/min)
Figure 9 Fraction B of Water Sample 2 (1.5 mL/min)
Figure 10 Fraction B' of Water Sample 2 (1.5 mL/min)



Bejoy S. Das, Ph.D.
Research Scientist
Department of Applied Chemistry

BSD:EL

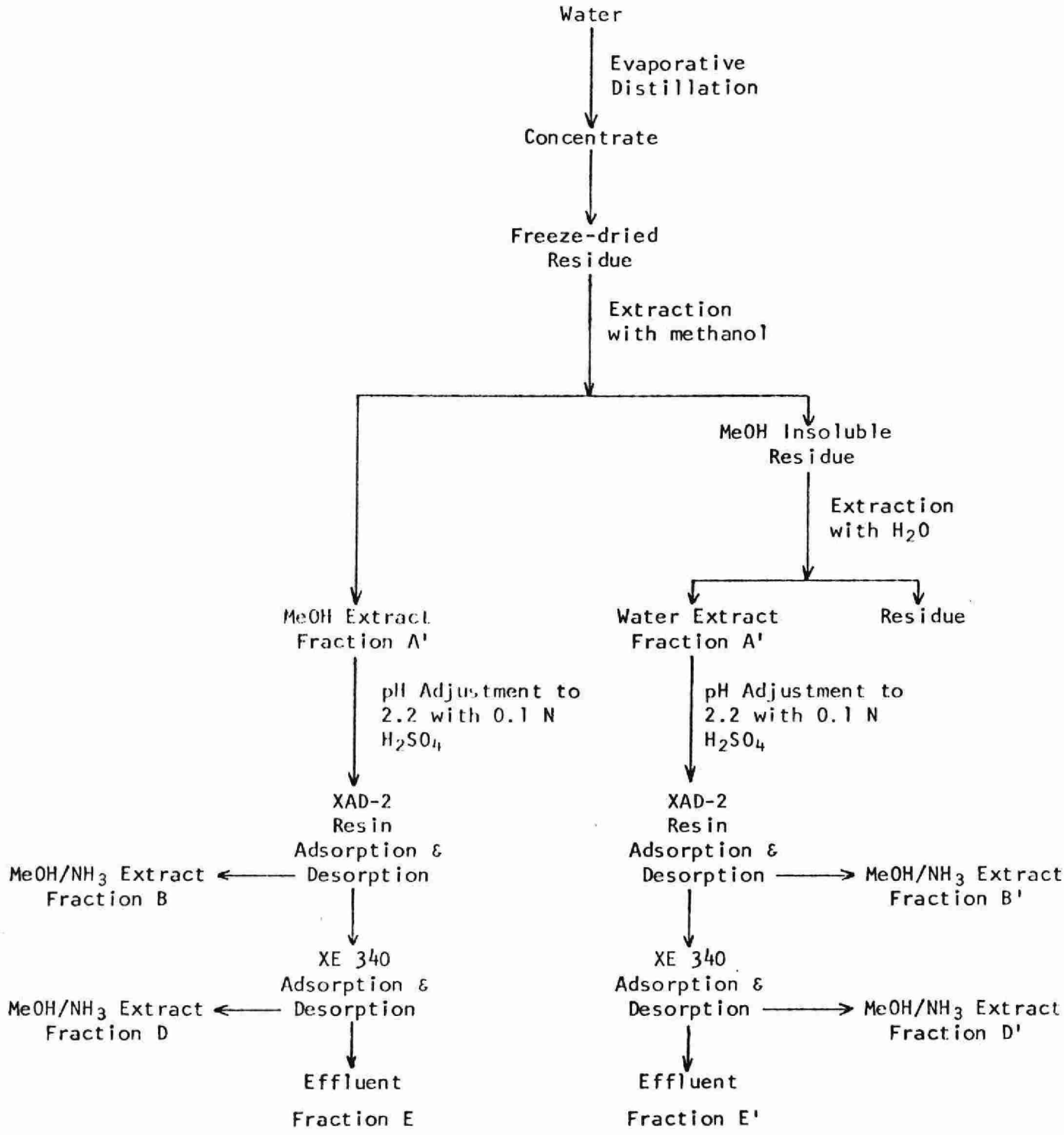


FIGURE 1: Fractionation Scheme

TABLE I: SEHPLC Analysis of Stoufville Water Samples

Sample No.	Fraction	Retention Time* @ 1 mL/min (min)	Retention Time @ 1.5 mL/min (min)	MWw
1	(B)	Peak I 25.9 Peak II 27.8 Peak III 32.2 (Fig. 3)	Peak I 15 Peak II 16.4 Peak III 19.6 (Fig. 3A)	∿16,000 ∿14,500 ∿10,000
	(B')	Peak I 25.9 Peak II 27.8 (Fig. 4)	Peak I 15 Peak II 16.4 (Figure 4A)	∿16,000 ∿14,500
	(D) (Fig. 5)	-	Peak I 15.0 Peak II 16.4 Peak III 19.6	∿16,000 ∿14,500 ∿10,000
	(D') (Fig. 6)	-	Peak I 16.4 Peak III 20.4	∿14,500
	(E) (Fig. 7)	-	Peak I 15.0	∿16,000
	(E') (Fig. 8)	-	No peak	No peak
2	(B) (Fig. 9)	-	Peak I 14.5 Peak II 15.6 Peak III 18.8	∿17,500 ∿15,000 ∿11,500
	(B') (Fig. 10)	-	Peak I 14.49 Peak II 15.6 Peak III 18.8	∿17,500 ∿15,000 ∿11,500

* Chromatographic conditions in the text

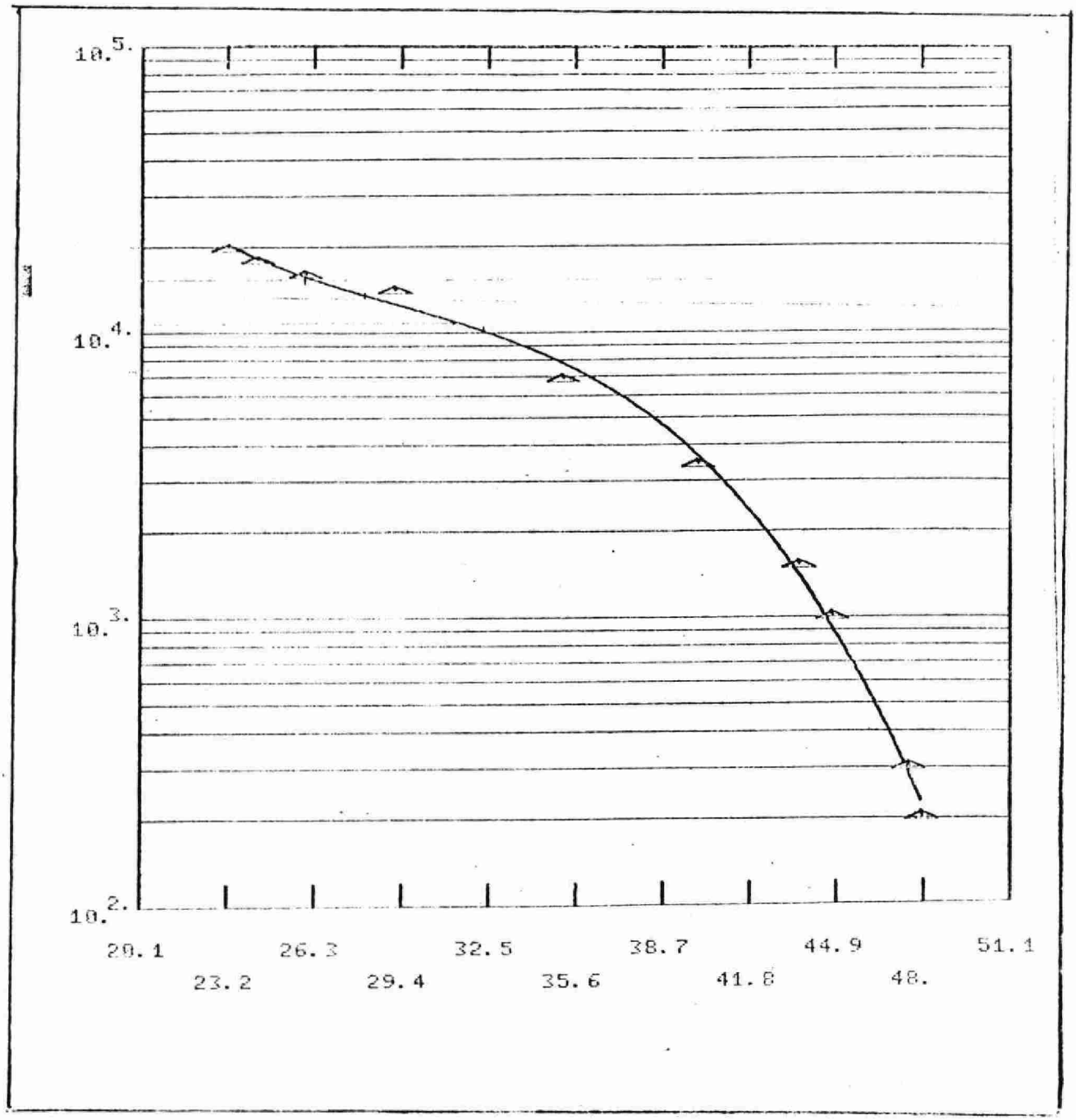


Figure 2: Calibration Curve
(SE HPLC Conditions in the text: 1.0 mL/min)

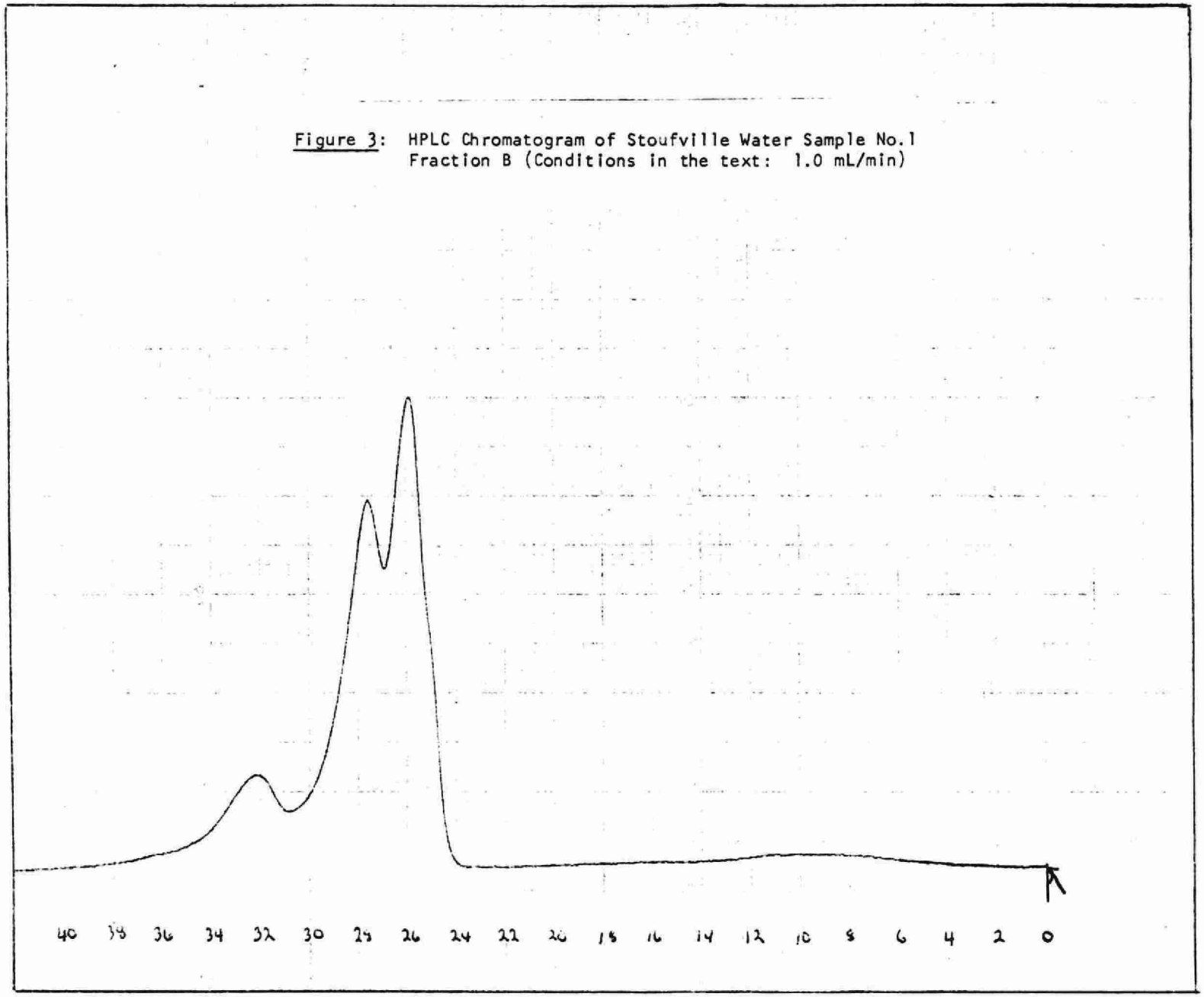


Figure 3: HPLC Chromatogram of Stoufville Water Sample No.1
Fraction B (Conditions in the text: 1.0 mL/min)

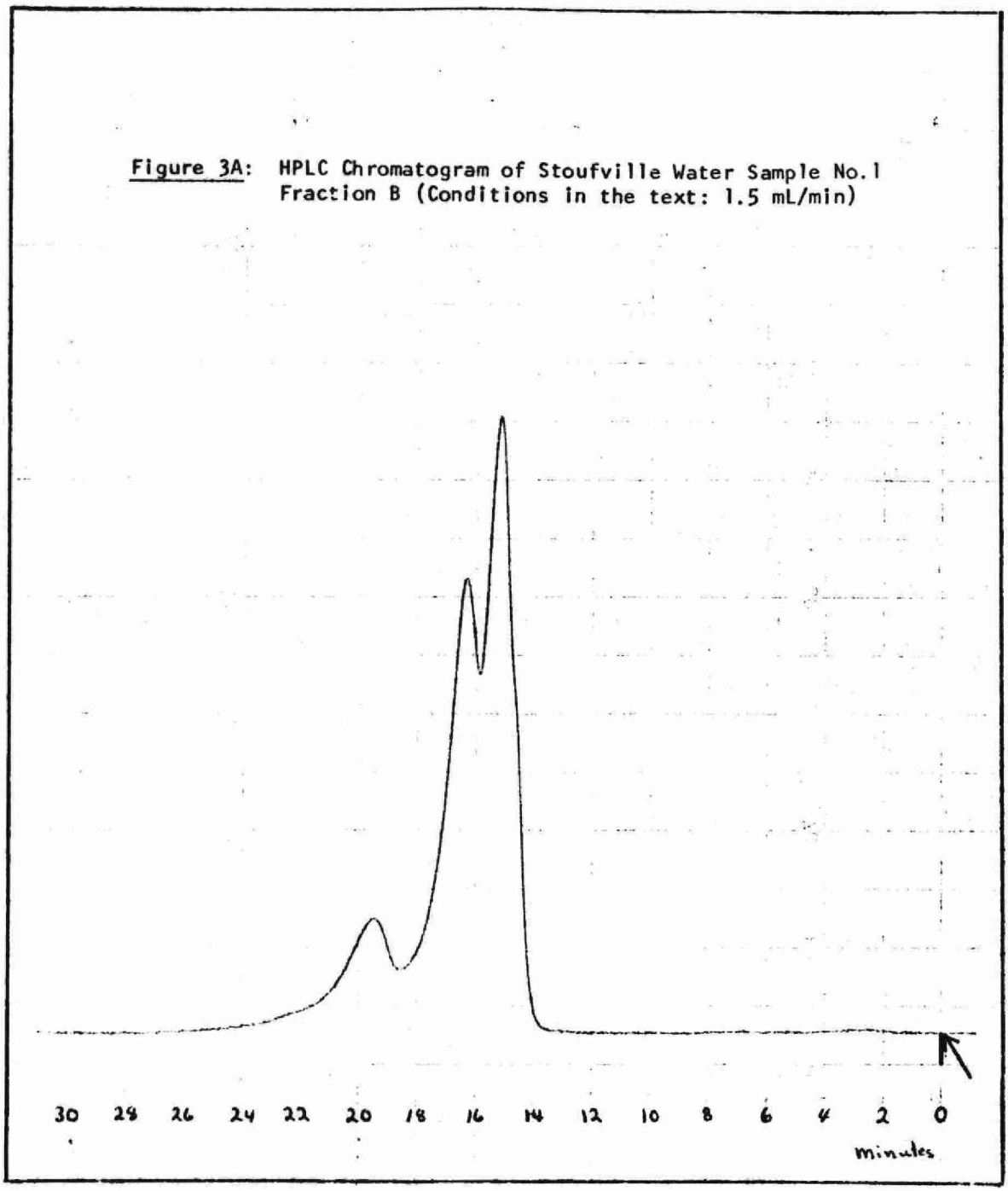


Figure 3A: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction B (Conditions in the text: 1.5 mL/min)

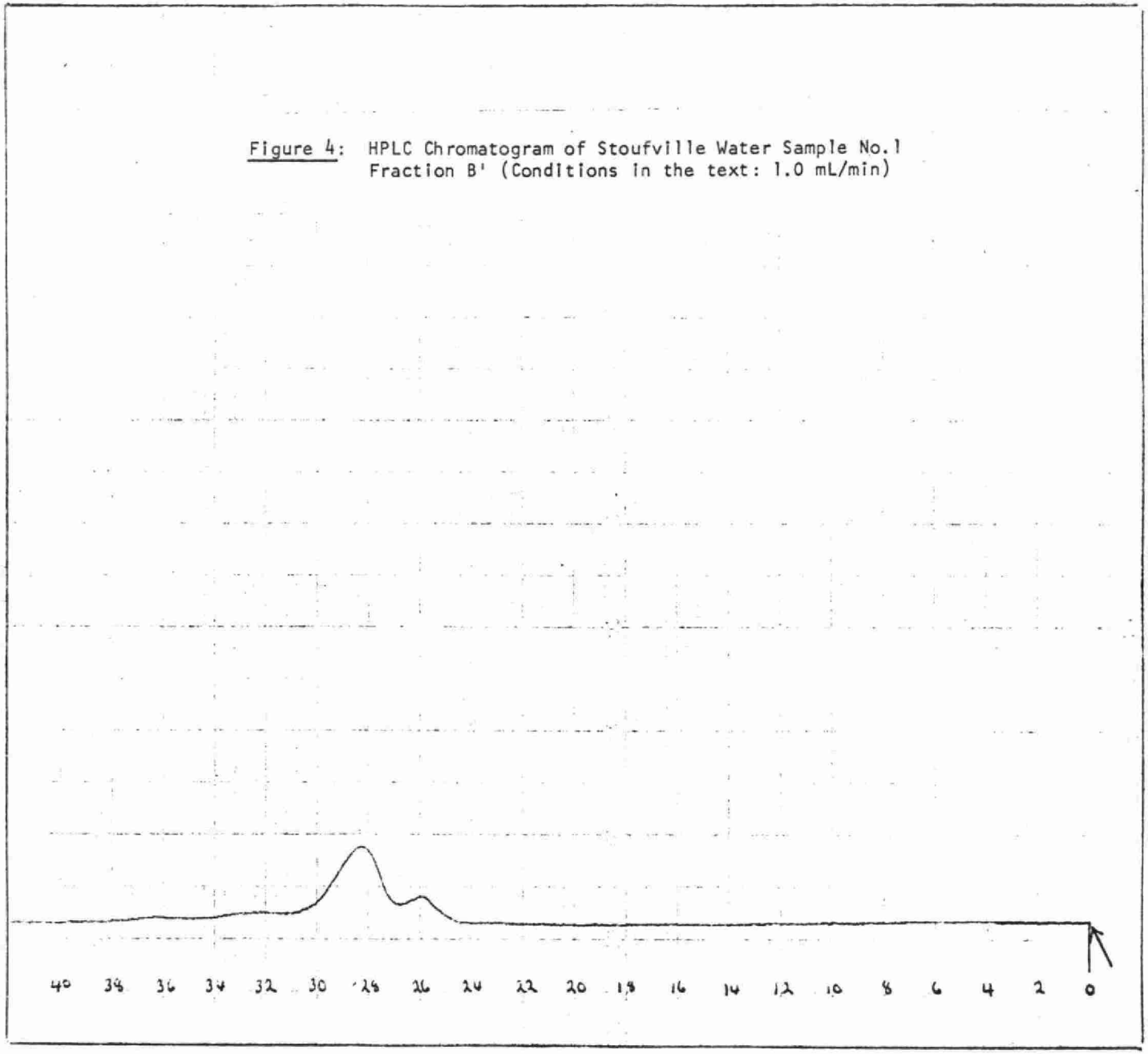


Figure 4: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction B' (Conditions in the text: 1.0 mL/min)

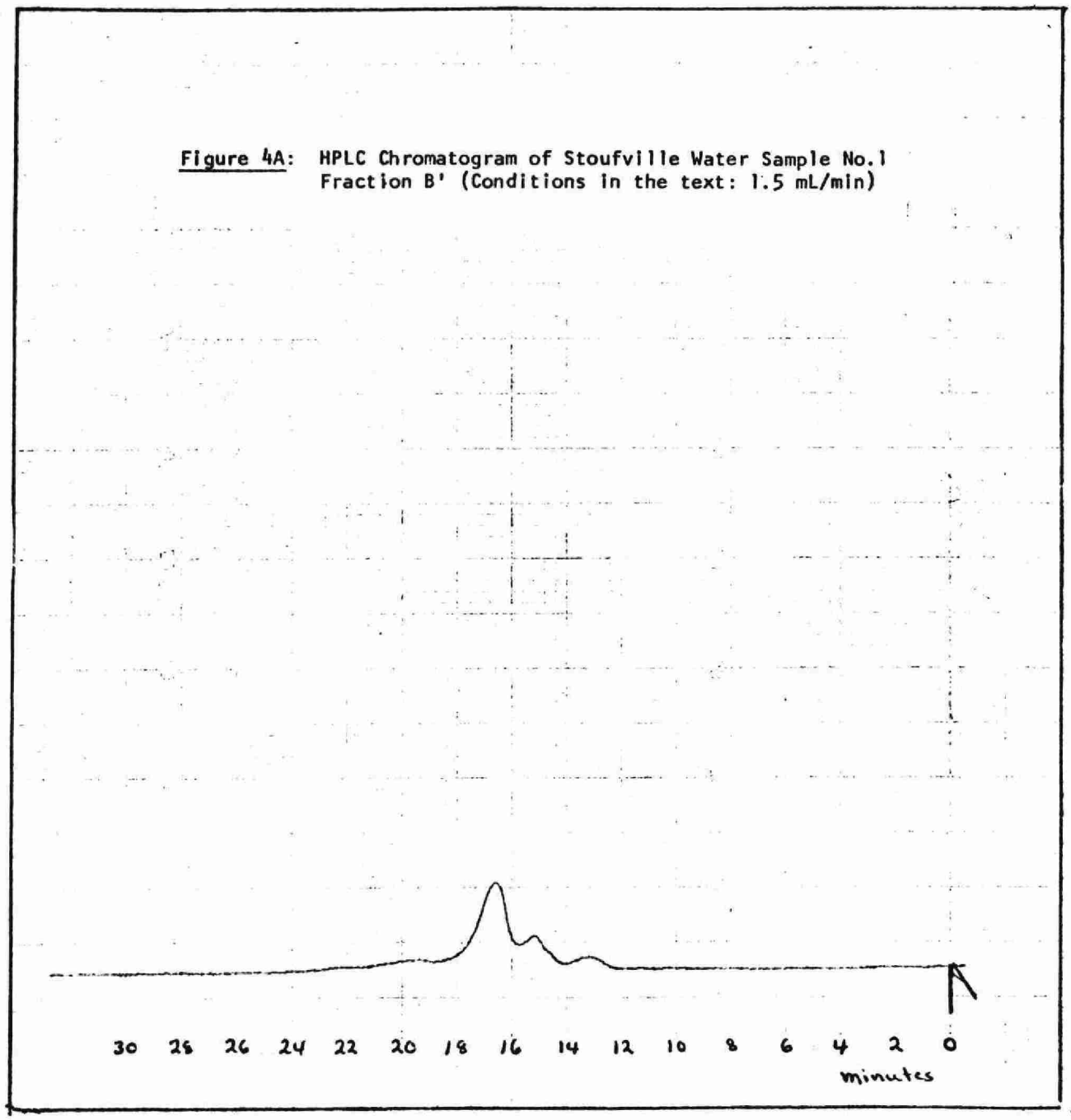


Figure 4A: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction B' (Conditions in the text: 1.5 mL/min)

Figure 5: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction D (Conditions in the text: 1.5 mL/min)

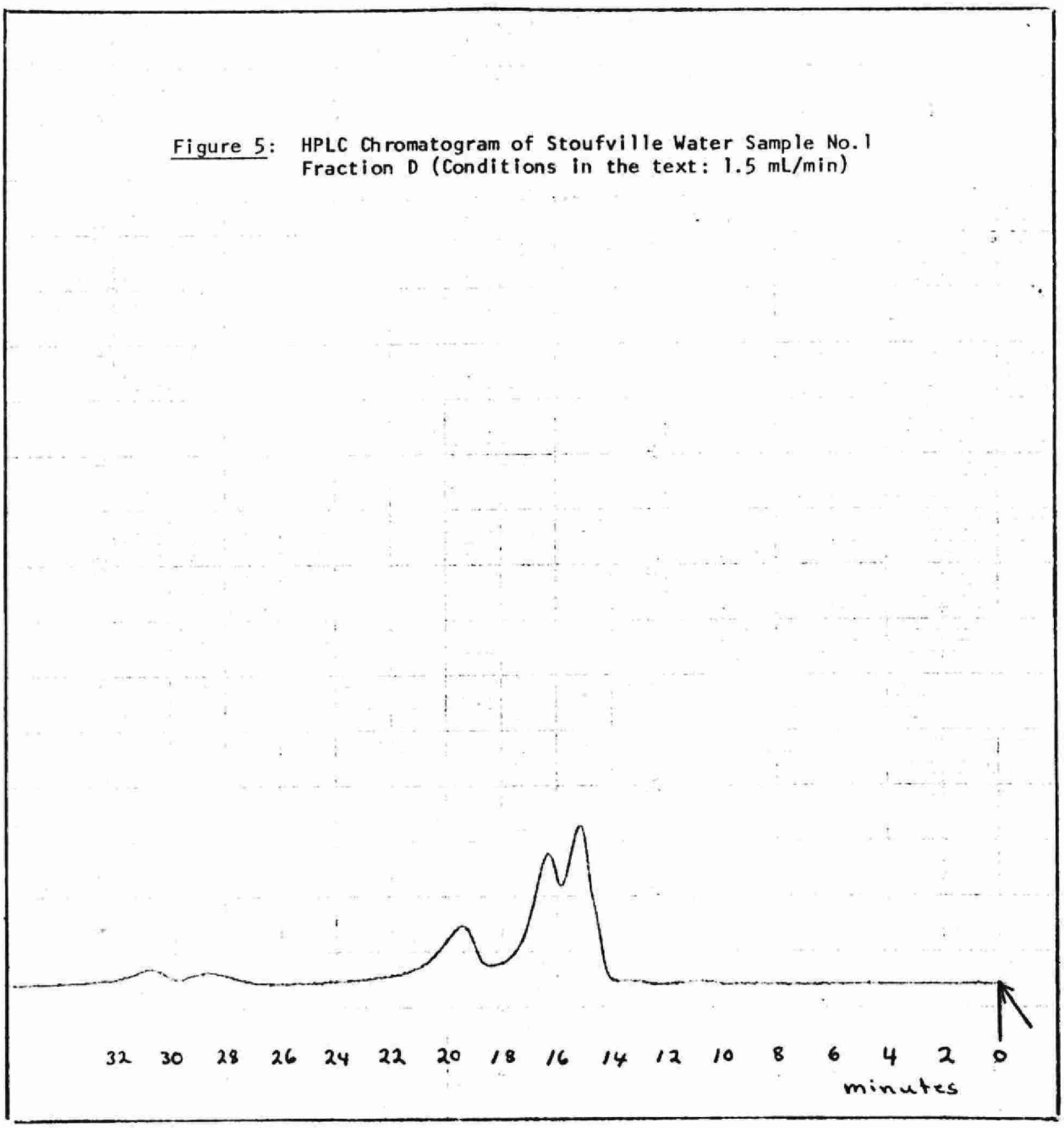


Figure 6: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction D' (Conditions in the text: 1.5 mL/min)

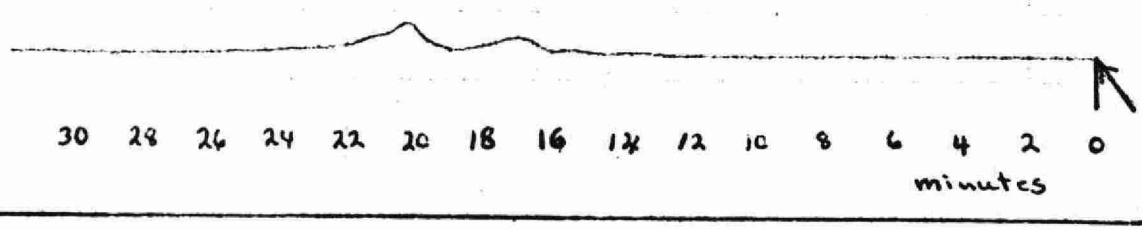
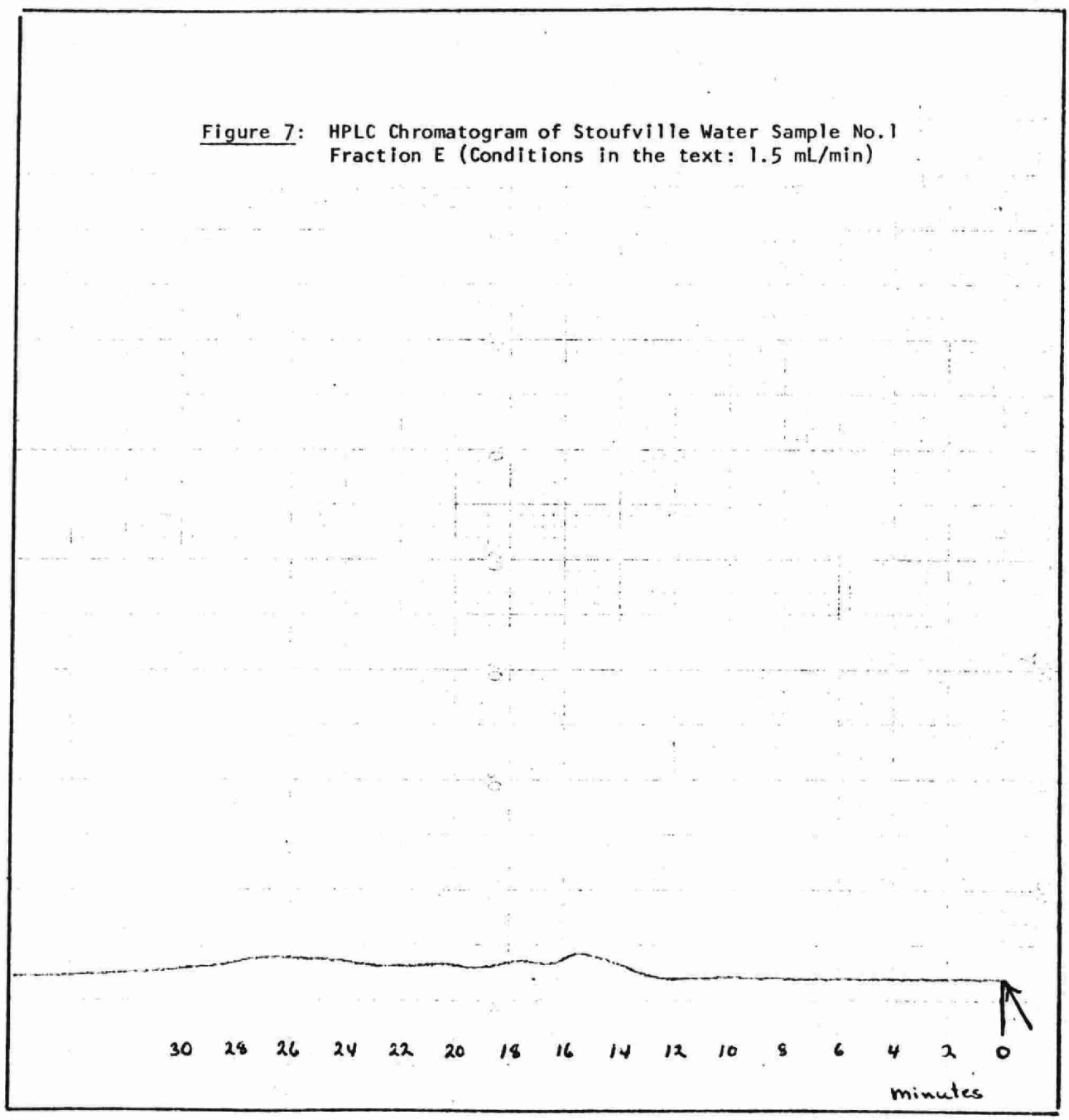


Figure 7: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction E (Conditions in the text: 1.5 mL/min)



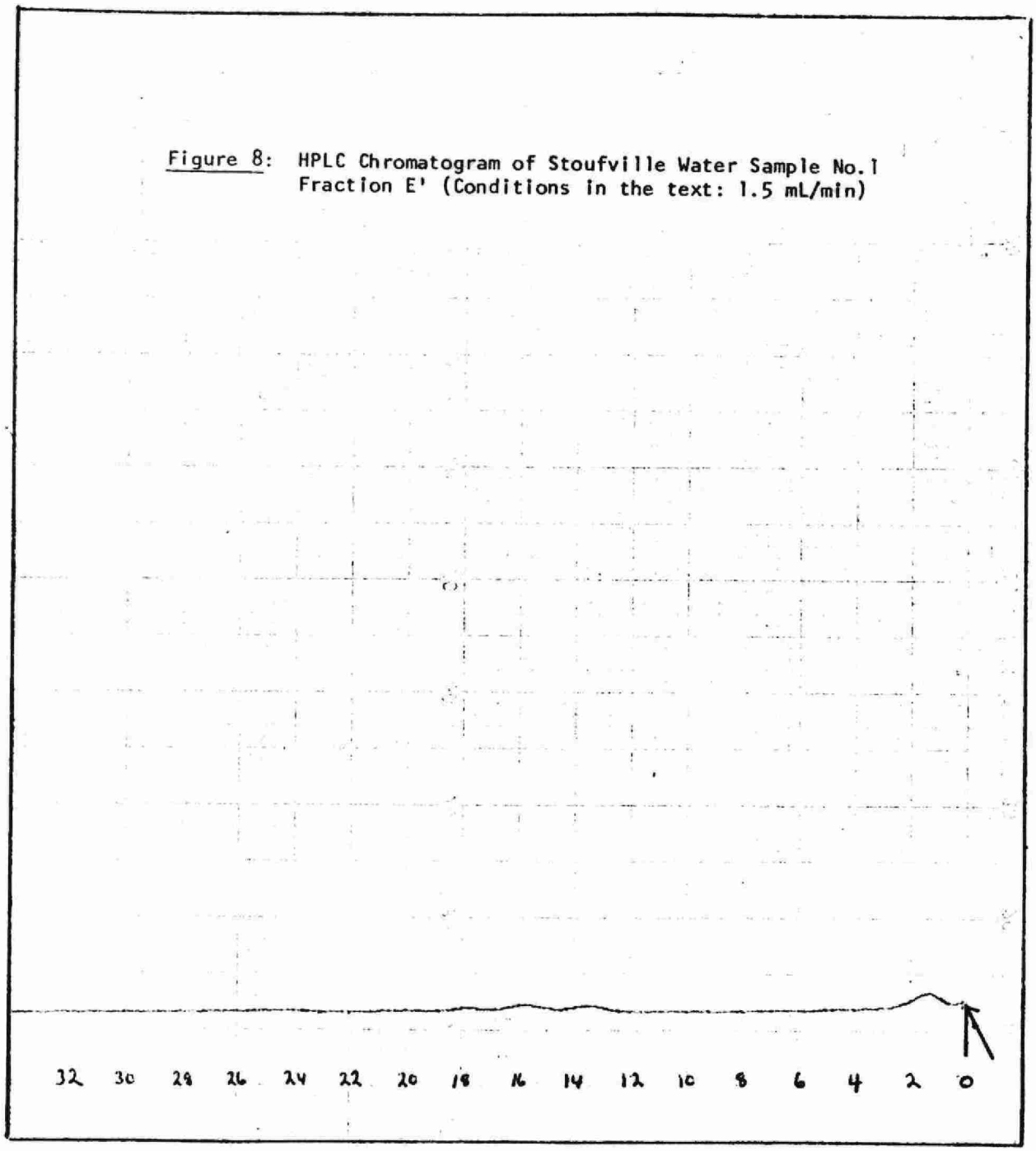


Figure 8: HPLC Chromatogram of Stoufville Water Sample No.1 Fraction E' (Conditions in the text: 1.5 mL/min)

Figure 9: HPLC Chromatogram of Stoufville Water Sample No. 2 Fraction B (Conditions in the text: 1.5 mL/min)

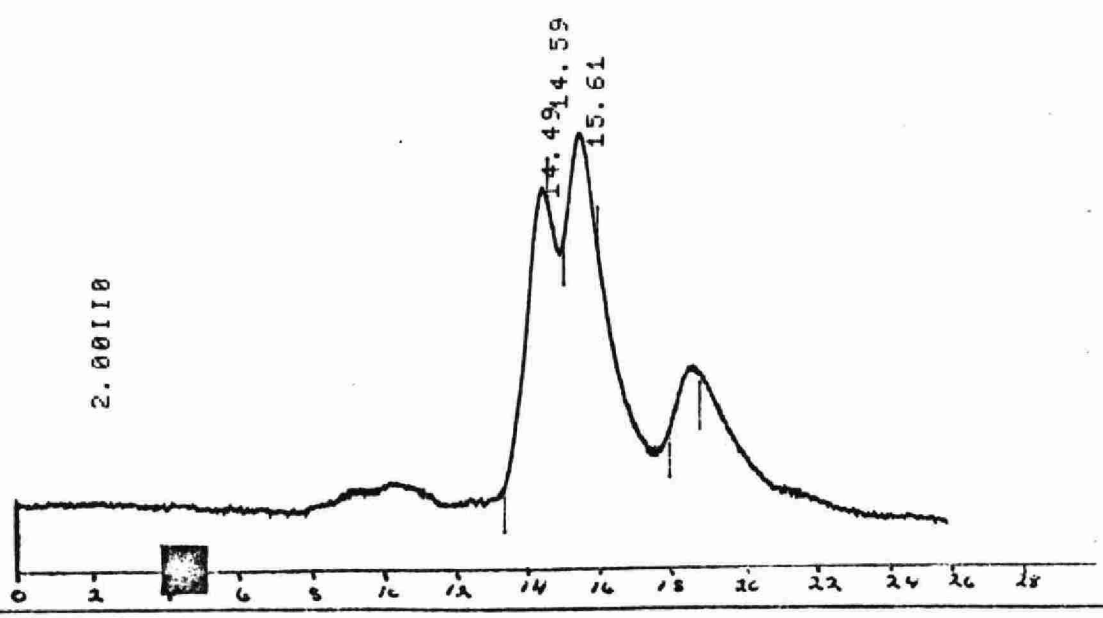
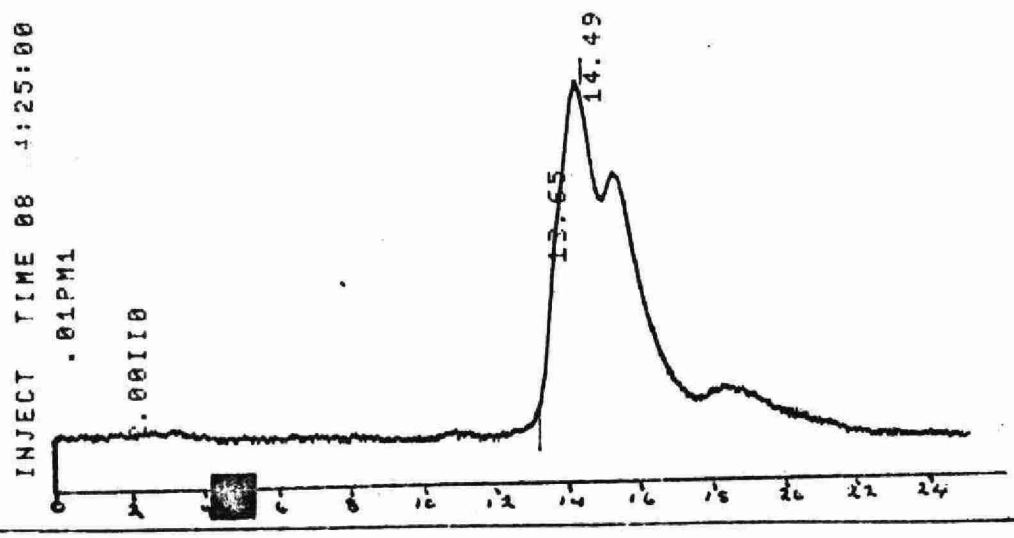
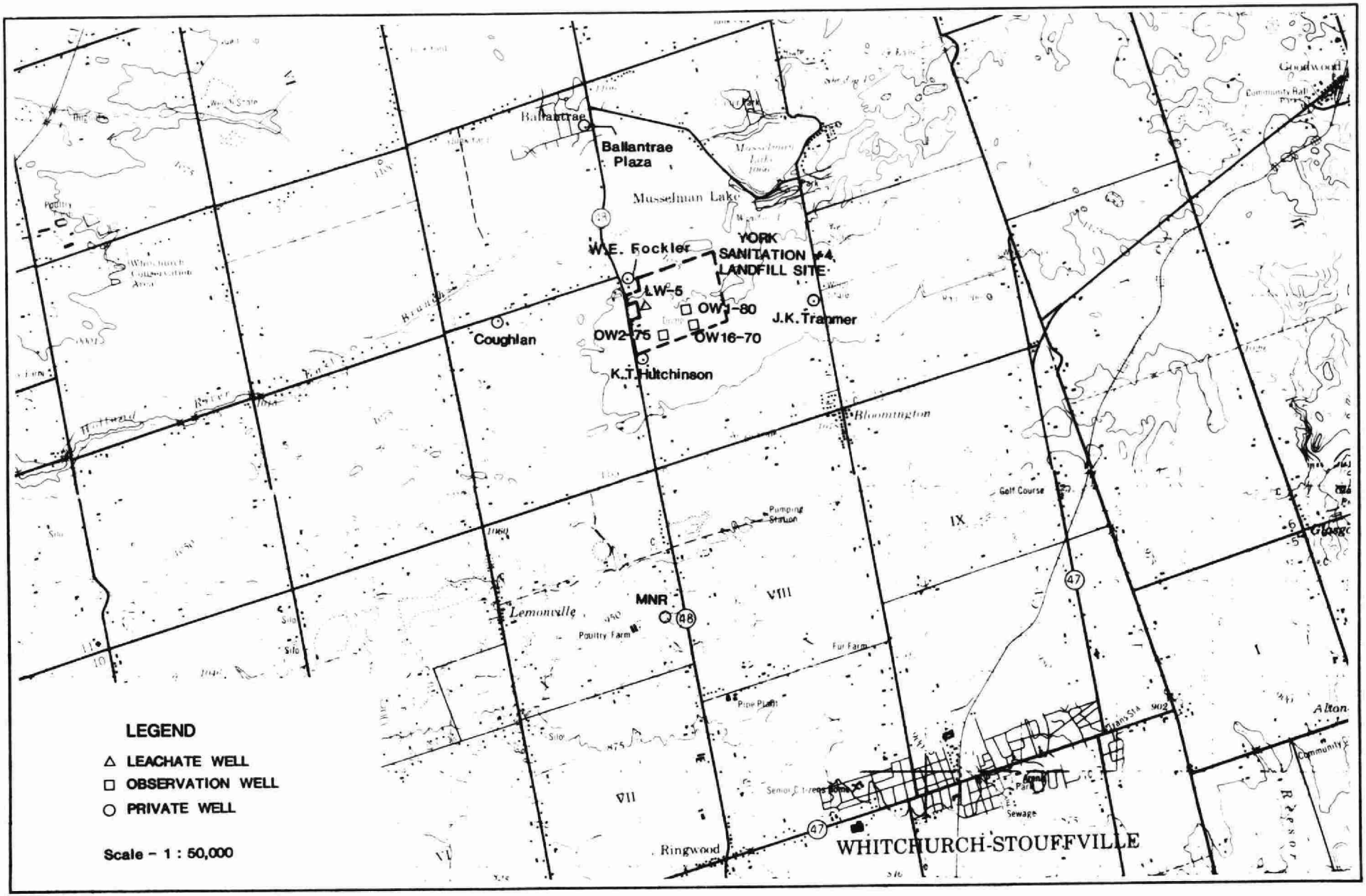


Figure 10: HPLC Chromatogram of Stoufville Water Sample No.2 Fraction B' (Conditions in the text: 1.5 mL/min)



F. MAP OF SAMPLE SITES



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